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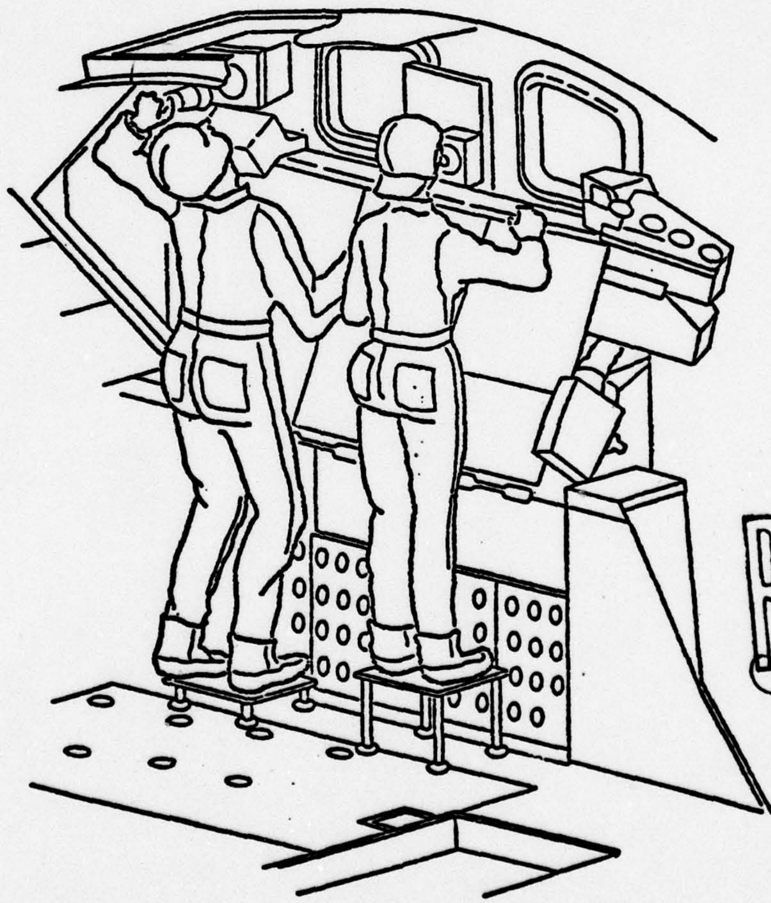
STANDARD TEST RACK
CONCEPT DEFINITION STUDY
MANNED INTERFACE DEFINITION



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STANDARD TEST RACK CONCEPT DEFINITION STUDY

STR

MANNED INTERFACE DEFINITION.

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Prepared for the

HEADQUARTERS

SPACE AND MISSILE SYSTEMS ORGANIZATION

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

DOD Standard Test Rack Manned Interface Definition for Shuttle Sortie Flight Operations for typical DOD experiments and tests in orbit. Includes ground-based, orbital and automated control approaches.

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SECTION 1
SUMMARY

1.1 INTRODUCTION

Except for such missions as the Apolio moon landing and Skylab programs, most space missions have been carried out using automated spacecraft controlled from the ground. The advent of the shuttle again introduces the possibility of mission roles for man in space. The shuttle carries free flier and sortie payloads. (See Figure 1-1) Free fliers are those payloads which are transported into space and deployed from the shuttle to become typical automated spaceeraft. Sortie payloads are transported into space but remain attached to the shuttle during their total mission life. These sortie missions of up to 30 days are exemplified by the NASA Spacelab missions, with a manned Habitat or with equipment mounted on cradles in the Orbiter cargo bay. This latter mode is of primary interest since it allows for experimental proofing flights of DOD equipment being developed for use on automated spacecraft. Other studies such as Reference 1 have shown this mode of testing to be an economical approach as compared to testing on automated spacecraft either as primary or "piggy-back" payloads. The sortie payload mode can also be used for operational missions.

This study analyses the use of man in support of shuttle sortie missions with payloads mounted on the Standard Test Rack (defined in Reference 1) in the Orbiter cargo bay. (See Figure 1-2) A group of candidate STP payloads, representing a cross-section of all STP payloads, was selected to be used to provide baseline payloads operational requirements. These payload requirements were analyzed and the operational activities identified. The performance of these activities was assigned to man or to automated equipment using a criteria developed to evaluate each funtion. A typical manned activity time line was developed for a specific payload combination and specific manned activities were defined. In parallel with these manned activity

FIGURE 1-1 SHUTTLE WITH SORTIE PAYLOADS

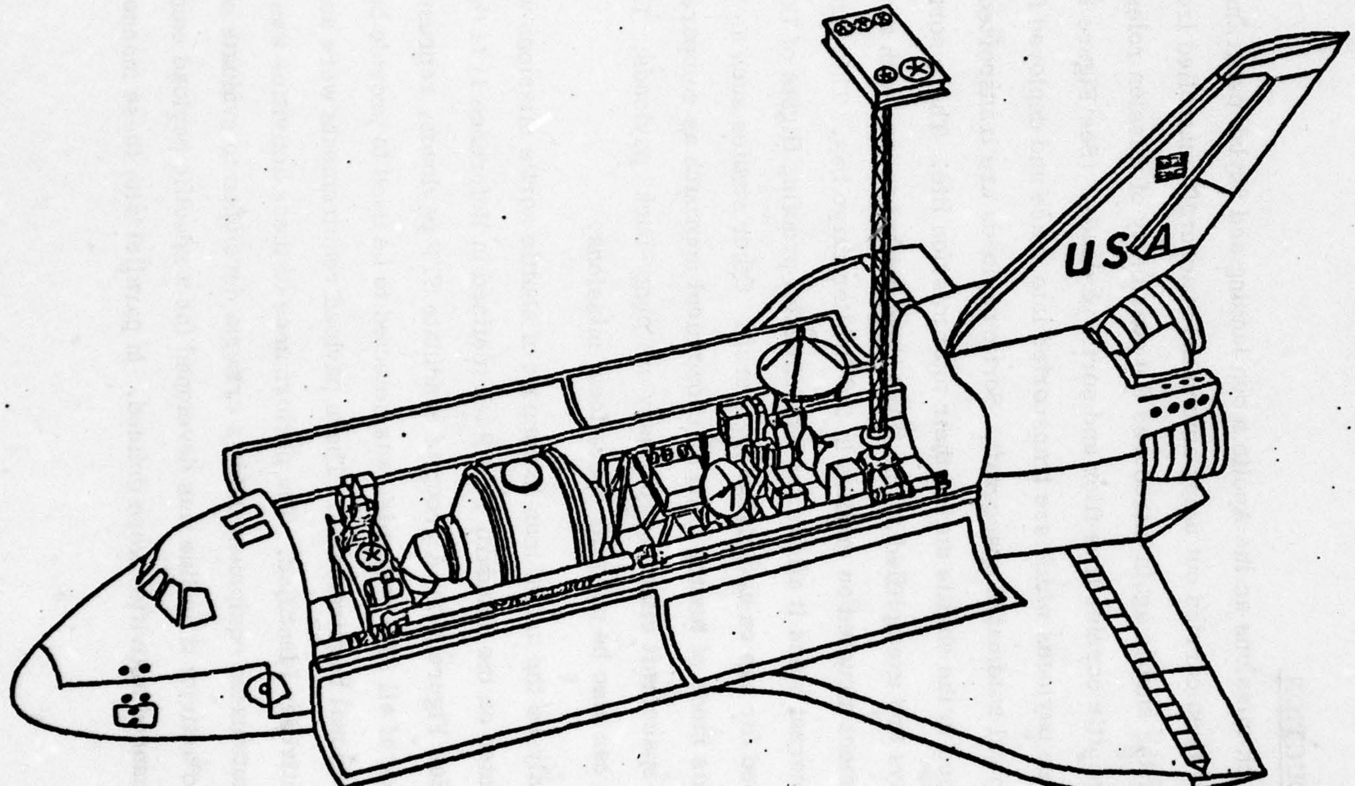
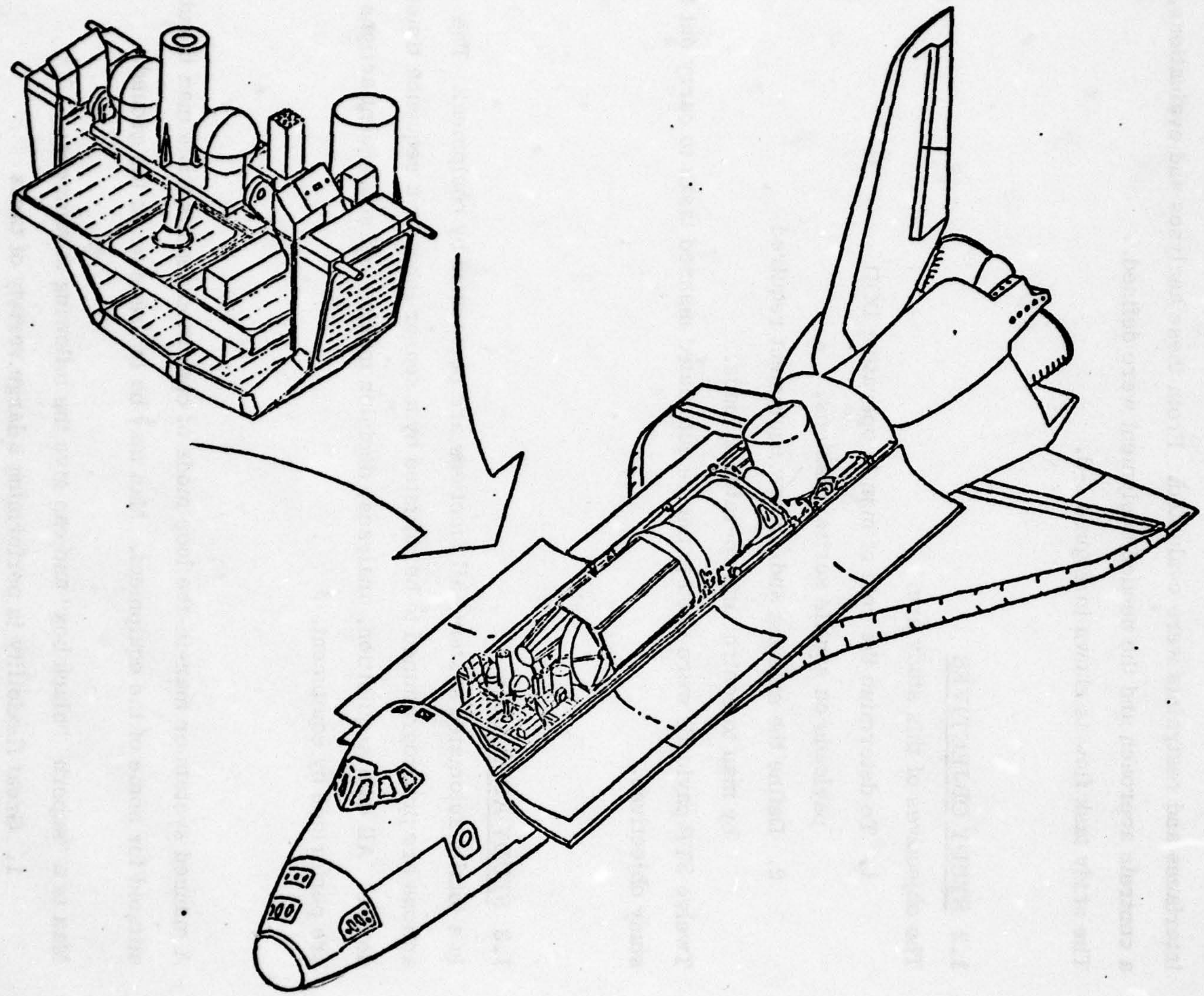


FIGURE 1-2 PAYLOAD ON STR IN THE ORBITER BAY



analyses, the equipment required by man to operate and control the DOD payloads was analyzed. Requirements were determined, existing equipment surveyed (including DOD and NASA control equipment), and the Orbiter and the AFT Flight Deck (AFD) interfaces and restraints were evaluated. From these analyses and evaluations, a controls approach and the needed equipment were defined.
The study task flow is shown in Figure 1-3.

1.2 STUDY OBJECTIVES

The objectives of this study are:

1. To determine the role of man in operating DOD payloads on shuttle sortie missions.
2. Define the existing and/or new equipment required by man to control and operate payloads.

Twelve STP payloads were used to derive automated manned tasks to carry out the study objectives.

1.3 STUDY APPROACH

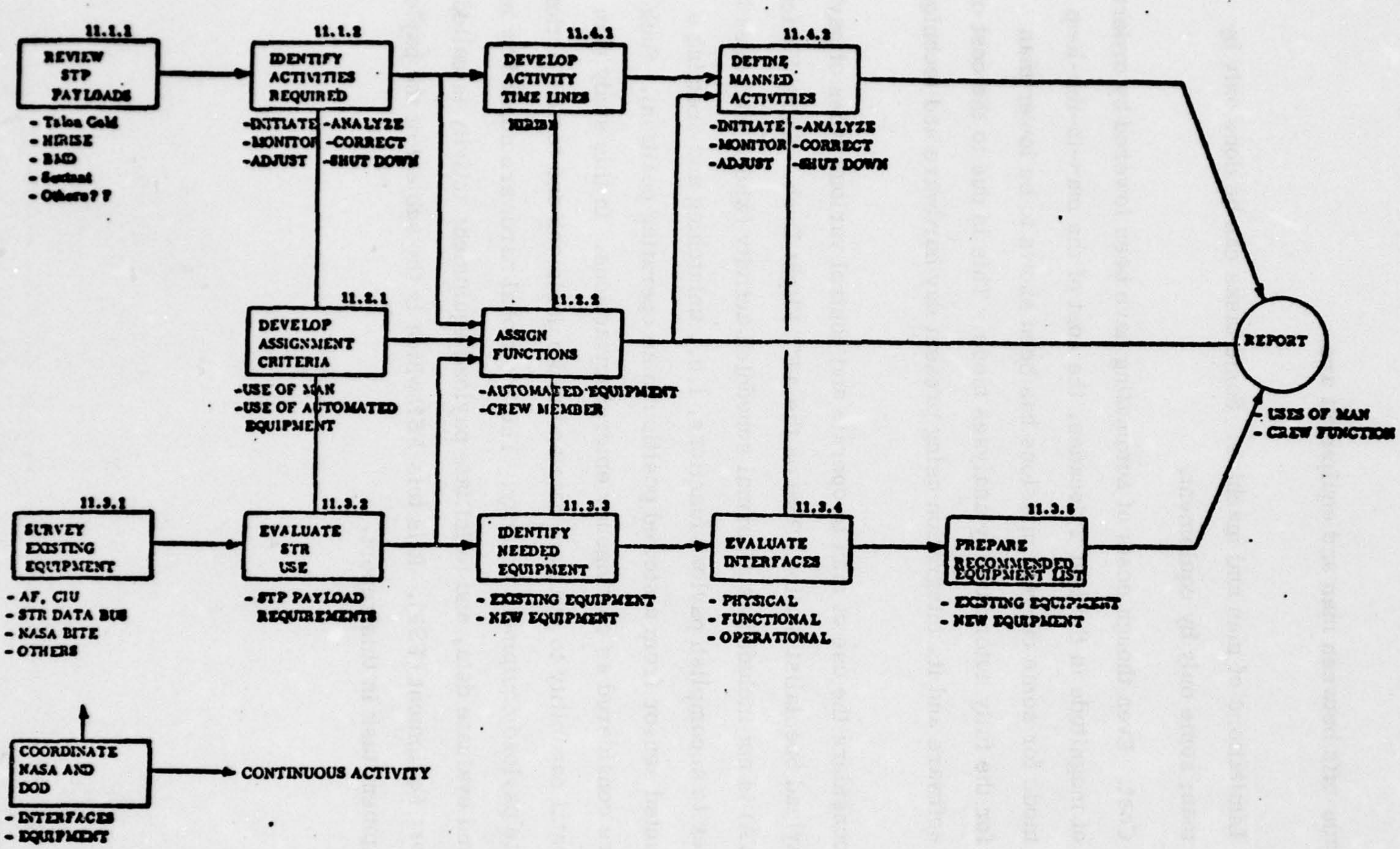
In a totally automated system, all functions are performed by equipment. The actions are preprogrammed to be initiated by a sensor input or a sequence timer device. All data acquisition, analyses, decision making and subsequent actions are performed by equipment.

A manned system or man-in-the loop mode of operation results when man is substituted for some of the equipment. Man may be in space or on the ground.

Man is a "superb" "black box" and can give the following advantages:

1. Great flexibility in performing a large variety of tasks
2. Innate adaptive intelligence to utilize his flexibility.

Figure 1-3 STR Manned Interface Definition Study - Task Flow



3. The analyses he can do is limited only by the tools provided.

The real trade-offs between man and equipment are:

1. Limitations of man and machine. Some tasks can be done only by man; some only by equipment.

2. Cost. Even though costs of automating have been lowered by orders of magnitude in the last 2 decades, the cost of the man-in-the-loop mode for some current missions has been shown to be lower than for the fully automated by analyses mode. This is due to the cost of software and its integration using present day hardware and techniques.

This study considers the use of man to operate and control various types of payloads from the Payload Specialist Station (PSS) on the AFT Flight Deck. Extra Vehicular Activity (EVA) is not included as a normal scheduled activity (where man uses his muscle power to accomplish payload functions, i.e., unlatching and erecting a column-mounted sensor from a stowed position to an operating position). Such EVA activities are considered as contingency emergency actions. In this study man uses his mental capability to evaluate data and make decisions and to take actions which initiate payload equipment activity. The additional hardware needed by man to acquire and evaluate data, and to initiate payload equipment activity is called Flight Support Equipment (FSE). It is this FSE which is the subject of the payload control equipment task in this report.

SECTION 2

CONCLUSIONS AND RECOMMENDATIONS

2.1 Conclusions

The purpose of the STP payload missions is to provide scientific data and that which verifies the performance of equipment or concept. Sky lab experience showed that in orbit, manned control capability should be maximized for long time operations for missions requiring day-to-day or orbit-to-orbit data evaluation and action planning. Such control increased the quantity and quality of the data obtained and improved the chance of mission success.

The major conclusion of this study is that there is a significant role for man in certain STP payload programs. Although not required on every mission, a significant number of missions have operation characteristics that allow man-in-the-loop to perform payloads control activities, generally at a lower cost than totally automated payloads.

A second important conclusion is that crewmen should use a dedicated payloads control system provided on the AFD to control and operate payloads in the Orbiter bay. This allows for flexibility and ease of integration. Predicted lower costs particularily make this a desired approach.

A summary of the conclusions reached in this study are contained in Table 2-1.

2.2 Recommendations

The following tasks are recommended to initiate activity in establishing the depth of man's role and defining the equipment requirements leading to development

Table 2-1 Conclusions of Manned Interface Study

MAJOR CONCLUSIONS

- MAN CAN PLAY A SIGNIFICANT ROLE IN CONTROLLING AND OPERATING STP PAYLOADS

- A DEDICATED CONTROL SYSTEM IS THE BEST MODE FOR PAYLOAD OPERATION AND CONTROL

OTHER CONCLUSIONS

- MANNED USAGE IS A FUNCTION OF
  - COST
  - UNIQUE PAYLOAD PERFORMANCE REQUIREMENTS
  - ORBITER RESTRAINTS

- COST DRIVERS ARE
  - SOFTWARE
  - SOFTWARE INTEGRATION
  - TRAINING
  - EQUIPMENT

  MANNED VS AUTOMATED TRADEOFF

- IUS AND TELEOPERATOR CONTROLS PRESENT BEST POTENTIAL FOR PAYLOAD CONTROL COMMONALITY

- EXISTING DESIGN EQUIPMENT OPTIONS ARE AVAILABLE TO ASSEMBLE INTO A DEDICATED SYSTEM D CONTROL SYSTEM MA

of STP Payloads Control and Operating Equipment (PCOE).

Task 1 Define payload operating requirements using a survey form prepared for that purpose

2 Perform mission analyses using the payload requirements to determine the potentials for flights planned Shuttle missions, potential for multiple payload flights, etc.

3 Investigate the IUS and Teleoperator systems in depth

4 Define and cost a system with specific hardware, Orbiter interface and STR interface definitions

5 Perform an automated versus manned control study with cost tradeoffs.

These tasks should result in a definition of the depth and frequency of PCOE usage and the direction to be taken with regard to hardware and commonality with other systems.

SECTION 3

MANNED INTERFACE WITH STR PAYLOADS

3.1 INTRODUCTION

The Orbiter, by virtue of being a manned vehicle, provides a unique resqurce to accomplishing STP payload mission objectives. A trained and skilled crewman, can effectively augment the STP payload systems resulting in an increase in payload return without a proportional increase in cost.

A real time man-in-the-loop on orbit system offers operational benefits such as:

- o Target recognition
- o Quick look data analysis
- o Real time ground/flight interactions
- o Equipment adjustment
- o Equipment inspection
- o Contingency operations analysis and investigation
- o Hardware configuration changes
- o Equipment manipulation/assembly
- o System deployment support
- o Application software modifications
- o Operational mode selection
- o Etc.

To determine the applicable areas of manned interactions with respect to the potential benefits available for the STP missions, 16 payloads identified for STR interface and orbital support, were selected for the manned interface assessment. A typical mission sequence was developed which identified the mission by operational phase and further identified each phase by its basic activities to determine the applicable areas of operational activities. An assessment logic was developed to accommodate the available information describing each payload, and to determine those activities applicable for manned interaction or automated operation.

For the purposes of this study, contingency/malfunction activities were not addressed. These activities are highly dependent on the specific design of each payload and are the result of FMEA's, Failure Reports, System Functional Assessments and Test Results which become available through the course of the payload fab/test cycles.

3.2 STR PAYLOADS

Sixteen payloads were identified for assessing the manned interfaces required during their on-orbit phase of an STR shuttle flight. These payloads consisted of FARUV, BMD, PDMM, SLED, ROMS, SEXTANT, LRT, HIRISE, ATLAS, PRAT, LASSII, XUV, OGAO, OCMD and a deployable spacecraft (see Page 11). Of the 16 payloads, there was insufficient data available to perform the manned interface assessment for the PDMM and ROMS payloads. Therefore, they were excluded from the study. Additionally, since a deployable spacecraft is incorporated in the SLED and LASSII payloads, the independant deployable spacecraft was eliminated from the list of payloads since the operational requirements would be redundant. The remaining 12 payloads constitute the basis for the manned interface assessment. Table 3.2-1 itemizes those payloads and provides a brief description of each payload and its operational objective.

List of Payloads

FARUV	-	Far Ultra-Violet Camera
BMD	-	Ballistic Missile Division - Shuttle Target Measurement Program
PDMM	-	(unknown)
SLED	-	Space Laser Experiment Development
ROMS	-	Remote Ocean Measurement System
SEXTANT	-	Space Sextant
LRT	-	Lasercom Receiver Test
HIRISE	-	Geothermal Earth Targets Infrared Imaging System
ATLAS	-	Atmospheric Topside Laser Sounder
PRAT	-	Precision Release Accuracy Test
LASSII	-	Low Altitude Study of Ionospheric Irregularities
XUV	-	Extreme Utra-Violet Environment
OGAO	-	Optical Geophysics and Astronomical Observatory
OCMD	-	Optical Countermeasures Demonstration

TABLE 3-1 STR BASELINE PAYLOADS

Payload	Brief Description
FAR UV	The experiment consists of two orbiter bay mounted Schmidt Cameras having different wavelength sensitivities and fine pointing capability. Payload data will be recorded on film for ground based analysis. Data will consist of imagery and photometry of naturally--occurring and man made emission phenomena in near earth space.
BMD	The experiment equipment will primarily be an orbiter bay mounted optical sensor designed for obtaining detailed measurements of optical signatures of exoatmospheric targets of interest to the BMD System. Data will be recorded on board and also downlinked to the ground.
SLED	The experiment configuration will be a combination of an orbiter released/ retrieved free flying spacecraft and an orbiter mounted laser optical system. The spacecraft acts as a cooperative target for orbiter based laser experiments in addition to ground originated laser experiments. Data is recorded on the free flying spacecraft with additional operational data downlinked to the ground.
SEXTANT	This experiment is primarily an automated payload designed to demonstrate the feasibility of autonomous satellite navigation and inertial attitude determination using a two-telescope orbiter mounted instrument. The instrument is basically designed for non-manned spacecraft and incorporates a mini computer, fault tollerant computer and special electronics. Data will be downlinked to the ground or temporarily stored on board if required.

TABLE 3-1 STR BASELINE PAYLOADS (cont'd)

Payload	Brief Description
LRT	The LRT is a communications experiment consisting of an orbiter mounted laser directed to a receiving satellite at synchronous altitude. Data transmitted up to the satellite will be retransmitted on another laser frequency to the orbiter and received by a laser optics module. Data will be compared and the error recorded on an on-board tape recorder.
HIRISE	This experiment's primary instrument is a gimballed optical system mounted in the orbiter bay and is designed to collect data for characterizing geothermal sites on a global basis. Data collected from selected sites will be processed and stored in an on board storage module.
ATLAS	The Atlas Experiment is an operational application and demonstration of the performance of a topside laser sounder in measuring the atmospheric density and aerosolin the upper troposphere and stratosphere. The experiment consists of a ruby laser transmitter and yoke mounted telescope receiver. Data takes will be conducted during the orbital night phase with all data recorded on board.
PRAT	This experiment is designed as an orbital test consisting of the release of test objects, under controlled conditions, to examine their detailed relative trajectories and determine the magnitude of their induced release perturbations. Data will be telemetered from the released objects and recorded on board the orbiter in addition to hand held high speed photographic data. The released objects are to be recovered at the conclusion of the test.

TABLE 3-1 STR BASELINE PAYLOADS (cont'd)

Payload	Brief Description
LASS II	**LASS II is a combination of a free flier and orbiter based equipment designed to measure certain ionospheric parameters relevent to the phonomenon of VHF/UHF scintillations to better understand the cause-effect relationship between plasma instabilities, ionospheric irregularities and scintillation phenomena. After free flier release, the orbiter will station keep, and through ground generated commands, the orbiter will receive transmissions from the free flier, directed through the ionospher. Data will be recorded on board the orbiter and then downlinked. The free flier will be recovered at the conclusion of experiment.**
XUV	**The experiment consists of a group of four detection systems designed to survey the XUV and X-Ray backgrounds of the earth's atmosphere and the sky. It is made up of one zenith sky monitor, two all sky monitors and one nadir pointing auroral monitor. It is primarily a passive type of experiment package with telemetry data downlinked to the ground and recorded, as required, on board the orbiter.**
OGAO	**The OGAO Experiment will obtain time histories, morphology and dynamics of auroral activities and equatorial regons of far UV emmissions. This will be accomplished by usinga gimbal mounted nadir viewing UV image converter camera, scanned by on board TV, pointed and controlled by the on-board crew. Video and sensor data will be downlinked when possible and recorded onboard when required.**
OCMD	**This experiment will demonstrate the performance of optical countermeasures against ground based lasers and determine the laser beam degrauation caused by by atmospheric turbulence and absorbtion. It consists of a boom mounted payload package and three orbiter mounted radiometers. It will operate in basically a receiving mode in conjuction with two cooperating laser ground sites. Data will be downlinked to ground and recorded onboard if required.**

3.3 Activities Required

There are two basic approaches which can be taken to identify the manned interface activities required for a sortie payload. A bottoms up approach provides the most detailed activity definition and identifies interfaces to the level of the number of controls and displays required, identification of required operational tools and support equipment, data display formats and any required on board application software. This approach demands a total understanding of the payload objectives, accurate and complete systems descriptions, functional flows and detailed schematics and design drawings. This level of definition is normally achieved between the preliminary and critical design phases of a given space mission.

A second method, or top down approach, generates categorical activities based on the operational requirements and objectives of the system under assessment. Although the level of interface definition cannot be as detailed as the bottoms up approach, it does establish the generic interface requirements needed for operational activities. It also requires considerably less detailed knowledge of the specific design features of the payload being assessed.

The generation of the manned activities required for the STR Payloads used the top down approach because detailed data such as schematics, functional flows, design drawing, etc., were not equally available for many of the identified STR Payloads. This is due to the various stages of development and procurement that these payloads are currently experiencing.

The top down approach identified 9 phases of orbiter flight which require operational interfaces for the STR payloads.

These were:

- Post Launch Activities
- Health and C & W Verification
- Brief (Prepass)
- Pre Pass Activities
- Experiment Operations
- Post Operation Configuration
- Brief (Post Pass)
- Pre Landing Preparations
- EVA

A total of 44 activities were established which both satisfy the STR Payload requirements and also the 9 on-orbit operational phases.

Table 3-2 lists each of the activities by operational phase and also provides a brief description of each activity. The specific "do" activities carried out by the Payload Specialist are defined and listed for each operational phase in Table 3-2A.

TABLE 3-2 CANDIDATE ON-ORBIT ACTIVITIES

PHASE	ACTIVITY	DEFINITION
POST LAUNCH ACTIVITIES	1. POST LAUNCH INSPECTION	Primarily a visual inspection of all experiment hardware which verifies the physical integrity of the equipment after exposure to the launch environment.
	2. RESTRAINT/ PROTECTIVE DEVICE REMOVAL	Release and/or removal of protective dust covers, shields, pins, bolts, holddowns and launch locks used exclusively for experiment protection and support through the launch phase.
	3. EXPERIMENT STOWAGE REMOVAL	Removal from a launch stowage location and implacement on the experiment of experiment hardware required to complete the on orbit experiment configuration.
	4. EQUIPMENT/PANEL POST LAUNCH RECONFIGURATION	Equipment and panel reconfigurations required to ready the experiment hardware from a launch safe configuration, to an on orbit operations compatable configuration.
HEALTH AND C & W VERIFICATION	5.* CONFIGURE FOR INITIAL POWER UP	Equipment and panel reconfiguration to ready the experiment equipment for an initial power up.
	6.* POWER ACTIVATION ENABLE	Initial on-orbit power up of experiment equipment. On-orbit manually enabled and manual/automated/ground control power up.
	7.* CAUTION & WARNING VERIFICATION	Initial verification of all experiment related C & W functions after power up.
	8. FUNCTIONAL HEALTH CHECK	Brief initial verification of the critical operational experiment functions.
BRIEF	9. PRE PASS BRIEFING	Verbal or uplinked message briefing of all experiment critical operational parameters for the upcoming experiment opportunities.

* These activities may occur before Activity Number 2 in some cases.

TABLE 3-2 CANDIDATE ON-ORBIT ACTIVITIES (cont'd)

PHASE	ACTIVITY	DEFINITION
PREPASS ACTIVITIES	10. PREPASS EQUIPMENT CONFIGURATION	Equipment and panel reconfigured to achieve the objectives of the operational pass (Described by checklist, uplinked message or verbal communication during prepass briefing).
	11. EQUIPMENT POWER UP	Power up of experiment equipment for upcoming operational pass.
	12. CAUTION & WARNING CHECK	Prepass verification of all experiment related C & W functions after power up.
	13. FUNCTIONAL HEALTH CHECK	Brief verification of the critical operational parameters for the functions required during the experiment pass.
	14. COMMAND LOAD VERIFICATION	Final pre experiment operations verification of controlling software, panel switch and selector settings and execution time tags required for the upcoming experiment operations.
	15. EQUIPMENT CALIBRATION	Final pre experiment adjustments to ensure experiment equipment is operating within the desired limits for a successful experiment pass.
EXPERIMENT OPERATIONS	16. MONITOR (Equipment/D&C/C&W)	Periodic or scheduled review of all experiment critical displays during the experiment pass for nominal and out of limits operation.
	17. MODE CHANGE	Selection of alternate operating modes (i.e., output power, pulse width, data rates etc.) during experiment operations in accordance with the established experiment protocol or for investigative experiment operational improvement.
	18. REAL TIME (R/T) DATA ANALYSIS	Evaluation of experiment generated scientific data concurrent with the experiment operations for the evaluation/improvement of experiment performance.

TABLE 3-2 CANDIDATE ON-ORBIT ACTIVITIES (cont'd)

PHASE	ACTIVITY	DEFINITION
	19. EQUIPMENT OPTIMIZATION	Experiment equipment selection/configuration and maintenance during operations to optimize and investigate experiment performance parameters. (i.e., preplanned software mods, alternate controlling electronics, alternate interfacing hardware, etc.).
	20. POINTING OPTIMIZATION	Control inputs to drive the data gathering sensors to the optimum pointing coordinates required to obtain experiment data.
	21. TARGET SELECTION	Control and pointing inputs to select the data source desired and/or providing the maximum source information available.
	22. EXPERIMENT OPERATIONS VERIFICATION	On going verification of key experiment functions, events and data to ensure the achievement of mission experiment success.
	23. DATA MANAGEMENT	Data editing, recording and/or down link selection of experiment sensor and equipment outputs required to assure rapid and complete experiment results evaluation.
	24. COMMAND INITIATION	Control input to initiate an event, sequence or controlling logic required for the successful accomplishment of the experiment.
	25. GROUND COORDINATION	Orbit-Ground interaction to coordinated experiment communications, sensor and source activities for optimum control, activation and operational planning.
	26. MANUAL PHOTOGRAPHY	On orbit hand held photographic coverage of identified experiment activities.
	27. EVENT ENABLE	Control input to allow automated, remotely initiated or time tagged commands to be executed.
	28. SEQUENCE/CONFIGURATION VERIFICATION	Operationally required feedback that a descrete or series of events have occurred and/or the physical configuration of the experiment has been altered in accordance with experiment operational plans.

TABLE 3-2 CANDIDATE ON-ORBIT ACTIVITIES (cont'd)

ACTIVITY		DEFINITION
	29. OPERATIONAL COMMENTARY	Verbal comments and descriptions of operational events generated by the operator during operational activities.
	30. COMMAND EXECUTION	Initiation of a descrete control to cause an event of series or events to occur.
	31. RMS ACTIVITIES	Any orbiter bay activity requiring the remote manpulator system and its controlling electronics and only accomplished by the on board crew.
	32. ELEVATION/ RETRACTION OPERATIONS.	Payload bay activities to either elevate the experiment hardware out of the orbiter bay or retract it back into the orbiter bay envelope.
	33. DEPLOY/JETTISON OPERATIONS	Orbiter bay activities to deploy or jettison all or part of the experiment package beyond the payload bay envelope for either normal experiment operations or scheduled reconfiguration for payload bay clearance.
POST OPERATIONS CONFIGURATION	34. EQUIPMENT POWER DOWN	Power down of experiment equipment to the standby or off condition following the powered up operational pass.
	35. EQUIPMENT SAFING/ RECONFIGURATION	Equipment and experiment control panel reconfiguration to a pre-determined safe condition allowing compatability to companion payload operations.
	36. DATA ANNOTATION AND STORAGE	Re editing packaging, identification and storage of experiment generated data from the operational pass for future, retrival, access and analysis.
BRIEF	37. POST PASS DEBRIEF	Verbal or uplinked message briefing of pertanent information regarding the completed experiment operations.

TABLE 3-2 CANDIDATE ON-ORBIT ACTIVITIES (cont'd)

ACTIVITY		DEFINITION
PRE-LANDING PREPARATIONS	38. EQUIPMENT STORAGE	Implacement of identified experiment hardware in storage locations/lockers in preparation for orbiter return and landing.
	39. COMPLETE POWER DOWN/ SAFING	Equipment and experiment control panel reconfiguration for minimum power or total power down of experiment hardware and the established safe configuration for the orbiter landing sequence.
	40. RESTRAINT/ PROTECTIVE DEVICE INSTALLATION	Installation of all protective devices hold downs and recovery locks required to ensure experiment equipment integrity during the entry and landing phase.
	41. DATA STORAGE	Final data storage of experiment generated data in their designated locations for the entry and landing phase.
	42. CAUTION & WARNING CHECK	Final verification of the applicable experiment C & W functions requiring monitoring during the reentry sequence.
EVA	43. PLANNED EVA*	Scheduled EVA Activities requiring a suited crewman performing experiment related functions in the orbiter bay.
	44. SPECIAL CONTINGENCY EVA	Anticipated contingency EVA activities requiring a suited crewman in the orbiter bay performing functions such as: o Manual jetteson of experiment appendages extending beyond the payload bay envelope. o Manual locking of gimbaled/articulating equipment o Automated equipment manual override features. o ETC.
		* NOTE: Determination of planned EVA activities requires specific design knowledge of the experiment hardware and a complete definition of the operational requirements.

TABLE 3-2 SPECIFIC ORBIT ACTIVITIES

ORBITAL ACTIVITY	POST LAUNCH ACTIVATION				HEALTH & C & W VERIFICATION				BRIEF	PREPASS ACTIVITIES						EXP OPS																		POST OPS CONFIGURATION			BRIEF	PRELANDING PREPARATIONS					EVA	
	1 Post Launch Inspection	2 Restraint/Portective Device Removal	3 Experiment Stowage Removal	4 Equipment/Panel Post Launch Reconfiguration	5 Configure For Initial Power Up	6 Power Activation/Enable	7 Caution Warning Verification	8 Functional Health Check	9 Pre-pass (Exp. Ops) Briefing	10 Pre-Pass Equiment Configuration	11 Equipment Power Up	12 Caution & Warning Check	13 Functional Health Check	14 Command Load Verification	15 Equipment Calibration	16 Monitor (Equip. /D&C/C&W)	17 ModeChange	18 R/T Data Analysis	19 Equipment Optimization	20 Pointing Optimization	21 Target Selection	22 Data Management	23 Command Initiation	24 Experiment Ops Verif	25 Ground Coordination	26 Manual Photography	27 Event Enable	28 Sequence Configuration Verification	29 Operational Commentary	30 Command Execution	31 RMS Activities	32 Elevation/Retraction Ops	33 Deploy/Jettison Ops	34 Equipment Power Down	35 Equipment Safing/Reconfiguration	36 Data Annotation Storage	37 Post Pass De-brief	38 Equipment Storage	39 Complete Power Down Safing	40 Restraint/Protective Device Installation	41 Data Storage	42 Caution & Warning Check	43 Planned EVA	44 Special Contigency EVA
CREWMAN ACTION																																												
INITIATE ACTIVITY		X	X	X	X	X	X	X		X	X			X	X		X		X	X	X	X	X	X		X	X			X	X	X	X	X	X			X	X	X	X	X	X	X
ADJUST SENSITIVITY LEVELS										X					X				X																									
SET EQUIPMENT LEVELS										X					X				X																X									
ESTABLISH OPERATING MODE									X	X					X		X		X																X									
MAINTAIN HOUSEKEEPING FUNCTION	X																																											
OBSERVE ACTIVITIES							X	X				X	X	X	X					X					X	X	X				X	X	X		X									
MONITOR ACTIVITIES		X		X		X	X	X			X	X	X	X	X	X																		X	X				X	X		X		
ANALYZE DATA							X	X				X	X	X	X			X			X	X		X			X															X		
EVALUATE RESULTS							X	X				X	X	X	X						X	X		X			X															X		
EDIT DATA																					X	X						X								X						X		
COMMUNICATE AND CONFER									X													X			X			X									X							
IDENTIFY MALFUNCTIONS							X	X				X	X		X	X																											X	X
DEVISE ALTERNATE OPERATING MODES							X	X				X	X		X	X																											X	X
INSPECT VISUALLY		X			X																										X	X	X		X									X
EQUIPMENT HANDLING						X	X	X		X					X											X					X				X	X		X		X	X	X	X	X
REPLENISH EXPENDABLES																						X				X																		
REPLACE PARTS (LIMITED)																																												
OPERATE MANIPULATORS																															X													
MANEUVER ORBITER																															X													

3.4 Functional Assessment Criteria

The activities defined in Section 3.3 cover the entire range of STP payloads and therefore do not apply, in total, to each individual payload. It was required to review each payload individually and in depth to drive out those functional activities applicable to its on orbit operation.

During the course of this assessment, payload documentation made available for this study was the basis for determining the applicability of each activity element. Due to the top level nature of the majority of these documents, it was necessary to augment the available data with experience factors gained from similar or parallel payload involvement, previous manned operations activities, and conceptual system configurations.

The result of this assessment is depicted in Table 3-3 where each payload is identified by its anticipated operational activities. Each activity, as it applies to each payload, is further coded by an *, X or 0 to indicate whether the information was a fact, implication or presumption. These were identified as follows:

* Fact	Data was directly available in the reference documents or the activity function was obviously required (i.e., power up of an electrically powered payload)
X Implication	Although no direct reference was made in the reference documentation, the activity function is implied by the system configuration (i.e., protective and launch restraint devices for gimbaled optical sensors)
0 Presumption	Payload configuration and complexity normally require activities of this nature to achieve operational success and/or readiness (i.e., functional health check or equipment calibration).

As can be seen in Table 3-3 many of the activity elements apply to all the payloads while some only apply to a specific few. To reduce redundant analytic efforts on each payload, a comparison of payload activities was performed to determine the representive payloads for further manned interface definition.

TABLE 3-3 PAYLOAD ORBITAL ACTIVITY SURVEY

ORBITAL ACTIVITY	STR PAYLOADS	No.	FAR UV	BMD	SLED	SEXTANT	LRT	HIRISE	ATLAS	PRAT	LASS II	XUV	OGAO	OCMD
POST LAUNCH ACTIVATION	Post Launch Insp.	1	O	O	O	O	O	O	O	O	O	O	O	O
	Restraint/Protective Device Removal	2	X	X	X	O	O	X	X	O	O	O	X	O
	Experiment Stowage Removal	3								X				
	Equipment/Panel Post Launch Reconfiguration	4	O	O	O	O	O	O	O	O	O	O	O	O
HEALTH & C&W VERIF.	Configure For Initial Power Up	5	O	O	O	O	O	O	O	O	O	O	O	O
	Power Activation/Enable	6	O	O	O		O	O	*	X	O	O	O	O
	Caution Warning Verification	7	O	O	O		O	O	O	O	O		O	O
	Functional Health check	8	O	O	O	O	O	O	O	O	O	O	O	O
BRIEF	PrePass (Exp ops) Briefing	9	X	O	O	O	O	X	O	O	O	O	*	
PREPASS ACTIVITIES	PrePass Equip. Configuration	10	X	X	X		O	X	X	*	X	*	X	X
	Equipment Power Up	11	*	*	*	*	*	*	*	*	*	*	*	*
	Caution & Warning Check	12	O	O	O		O	O	O	O	O		O	
	Functional Health Check	13	X	X	O	O	*	X			O			O
	Command Load Verification	14						O		O	O	*	O	O
	Equipment Calibration	15	O	O	O	O	O	O	O	O	O	O	O	O
EXP OPS	Monitor (Equip/D&C/C&W)	16	*	*	*	*	*	*	*	*	*	*	*	*
	Mode Change	17	*		O				*	*	O			
	R/T Data Anal	18								O				
	Equipment Optimization& Maint.,Assembly	19												O
	Pointing Optimization	20	*	*	*		*	*			O		*	
	Target Selection	21	*			*		*				*		
	Data Management	22		X	O			X		O			O	
	Command Initiation	23	*	*	*	*	*	*	*	*	*	*	*	*
	Experiment OPS Verif	24	*	X	*	X	X	X	X	*	*	X	*	X
	Ground Co-Operation	25	*	*	O	O	X				*		*	X
	Manual Photography	26								*				
	Event Enable	27			O					O	O			O
	Sequence Configuration Verification	28	X	X	X	X	X	X	X	X	X	X	X	X
	Operational Commentary	29	X					X		O		O		
	Command Execution	30	*	*	*	*	*	*	*	*	*	*	*	*
	RMS Activities	31		X	X					X	X			*
	Elevation/Retraction OPS	32		*	X					O	X	O		
	Deploy/Jett OPS	33		*	O					*	*			
POST OPS CONFIGUR-ATION	Equipment Power Down	34	*	*	*	*	*	*	*	*	*	*	*	*
	Equipment Safing/Reconfiguration	35	O	X	X		O	O	O	X	X	O	O	O
	Data Annotation Storage	36								X				
BRIEF	Post Pass De Brief	37	X	O	O			X		O	O	O	O	O
PRELANDING PREPARA-TIONS	Equipment Storage	38								X				
	Complete Power Down Safing	39	X	X	X		X	X	X	X	X	X	X	X
	Restraint/Protective Device Installation	40	X	X	O	O	O	X	X	O	O	O	X	O
	Data Storage	41								X				
	C & W Check	42	O	O	O		O	O	O	O	O		O	O
EVA	Planned EVA	43								O				
	Special Contigency EVA	44								O				

NOTE: * = FACT X = IMPLICATION O = PRESUMPTION

	GROUP A					GROUP B			GROUP C	GROUP D	GROUP E	
EXPERIMENT / REF ACTIVITY NUMBER	FAR UV ***	LRS	HIRISE	ATLAS	OGAO	BMD	SLED ***	LASS II	SEXTANT ***	PRAT ***	XUV	OCMD ***
3										X		
4									X			
6									X			
7									X		X	
9												X
10									X			
12									X		X	X
13				X	X					X	X	
14			X		X			X		X		X
17		X	X		X	X			X		X	X
18										X		
19												X
20				X					X	X	X	X
21			X		X	X	X		X	X		
23			X	X						X	X	
25										X		
26								X		X		X
28		X		X		X	X	X			X	X
30						X	X	X		X		
31						X	X	X		X	X	
32						X	X	X		X		
33		X		X		X	X	X		X	X	X
35									X			
36										X		
37		X		X					X			
38										X		
39									X			
41										X		
42											X	
43										X		
44										X		

TABLE 3-4 PAYLOAD ACTIVITY COMPARISON

The comparison of payloads was accomplished by arbitrarily choosing the FAR UV Payload as a baseline experiment and identifying activity differences for each individual payload to the FAR UV Payload. The result of this comparison is shown in Table 3.4. As can be seen, the payloads fell into 5 basic activity groups incorporating the full spectrum of identified operational activities. Activities (identified by the Ref. activity number) that were common to all payloads are not shown in the table since the table only denotes differences from the baseline FAR UV Payload. Each group was then reviewed to identify one representative payload which encompasses all the necessary activities identified for that group of experiments. It is important to note here that Table 3-4 only identified the differences from the FAR UV Payload and that difference can be either the presence or absence of a FAR UV payload activity. The result of this review was the selection of the FAR UV, SLED, SEXTANT, PRAT AND OCMD Payloads. Operational activities of these payloads do cover all of the previously identified activities and are identified by *** in the Table 3-4.

3.5 Functional Assessment

Functional implementation of on orbit activities can be achieved in three basic ways. One approach would be to have a totally automated system where a sequence of on orbit events occur in a predetermined manner initiated by a key event such as seperation switch, limit detector or time tag. A second method would be to initiate all events through ground commands determined through the use of ground based computers and operator knowledge. The third approach would be to provide the on board crew with all the necessary D & C interfaces to complete the events necessary for successful payload operation. Obviously no one single approach lends itself to the operation of payloads other than the least complex payload requiring a single event activation/deactivation during the course of its operational life. The fact that the payload is carried on a manned vehicle with interrupted communication links implies a mix of all three approachs to optimize the on orbit operations.

To determine the complexity factor associated with each one of the approaches each payload activity, for the five selected payloads, was qualitatively assessed in eight specific areas affecting payload complexity and implementation. Complexity is defined by the following list of component factors:

- o Requirements
- o Hardware
- o Software
- o Control Activities (data monitored, analysis, etc.)
- o Constraints and limitations (physical, data, etc.)
- o Safety Level
- o Performance
- o Reliability
- o Maintainability

A simple three level qualitative grading was used to indicate decreased complexity (+), no anticipated change to configuration (o) and increased complexity (-).

The eight specific areas graded for each activity were:

Equipment Location -	Relative to constraints on equipment access in the orbiter cabin and cargo bay.
Instrumentation -	Addition or reduction of required instrumentation to achieve/verify an operational activity/event.

Physical Configuration -	The affect on payload hardware complexity imposed by the selected approach.
Operational Flexibility -	The ability to react to real time changes maximizing payload return.
Safety -	Impacts incurred to maintain the safe operational environment of a manned vehicle.
Computer Usage -	Payload processor or orbiter GPC impacts
Software Requirements -	Impacts incurred through the development of payload applications software.
Security -	Impacts incurred in the maintenance of a secure control system.

Tables 3-5 through 3-9 show the results of this assessment for the five payloads. To the right of the grading columns in each table is the relative standing of the implementation methods. The standings are listed from left to right with "G" indicating a ground activity, "M" indicating an on orbit crew activity and "A" indicating an automated activity. The standings are separated by commas in most cases and a slash (/) in an either/or (equal) standing.

In general, the assessment results indicate the majority of the 44 activities for all five experiments are preferred to be performed by the on orbit crew. This preference was driven primarily by four of the eight specific areas under assessment. These were communication link requirements, operational flexibility, computer usage and software requirements. Of the four, computer usage and software requirement areas provide many of the functional capabilities which can supplement and/or replace crew activities. The trade off between using the crew vs on board computers and application software is the cost of developing and implementing the software system and the cost of training and training hardware required to attain crew operational readiness. To adequately perform this trade off requires detailed payload design, configuration and mission objective definition currently not available for this assessment.

TABLE 3-5 FUNCTIONAL ASSESSMENT - FARUV

ORBITAL ACTIVITY			EQUIPMENT LOC.	INSTRUMENTATION	PHYSICAL CONFIG	COMM.LINK REQ.	OPERATIONAL FLEX	SAFETY	COMPUTER USAGE	SOFTWARE REQ.	SECURITY		FAR UV
POST LAUNCH ACTIVITIES	POST LAUNCH INSP	G	+	-	0	-	-	0	-	-	-	-5	
		M	-	+	0	0	+	0	+	+	0	+3	M, A, G
		A	+	-	0	0	-	0	-	-	+	-2	
	RESTRAINT/ PROTECTIVE DEVICE REMOVE	G	0	0	0	-	-	0	-	-	-	-5	
		M	0	0	0	+	+	0	+	+	0	+4	M, A, G
		A	0	0	0	0	-	0	0	-	+	-1	
	EXP STOWAGE REMOVAL	G											
		M											
		A											
	EQUIP/PANEL POST LAUNCH RECONFIG	G	0	0	0	-	-	0	-	-	-	-5	
		M	0	0	0	+	+	0	+	+	0	+4	M, A, G
		A	0	0	0	0	-	0	0	-	+	-1	
HEALTH & C & W VERIFICATION	CONFIG FOR INIT POWER UP	G	0	0	0	-	-	0	-	-	-	-5	
		M	0	0	0	+	+	0	+	+	0	+4	M, A, G
		A	0	0	0	0	-	0	0	-	+	-1	
	POWER ACTIVATING ENABLE	G	0	0	0	-	-	0	0	0	-	-3	
		M	0	0	-	+	+	+	+	+	0	+4	M, A/G
		A	0	0	0	-	-	0	0	0	+	-1	
	CAUTION WARNING VERIFICATION	G	0	0	0	-	-	0	-	-	-	-5	
		M	0	0	0	0	+	0	+	+	0	+3	M, A, G
		A	0	0	0	0	0	0	0	-	+	0	
	FUNCTIONAL HEALTH CHECK	G	0	0	0	-	-	0	0	-	-	-4	
		M	0	0	0	+	+	0	0	+	0	+3	M, A, G
		A	0	0	0	0	0	0	0	-	+	0	
BRIEF	PREPASS BRIEFING	G	0	0	0	0	0	0	0	0	-	-1	
		M	0	0	0	-	0	0	0	0	0	-1	A, G/M
		A	0	0	0	0	0	0	0	0	+	+1	
PRE PASS ACTIVITIES	PREPASS EQUIP CONFIG	G	0	0	0	-	-	0	-	0	-	-4	
		M	0	0	0	+	+	0	+	+	0	+4	M, A, G
		A	0	0	0	0	0	0	0	0	+	+1	
	EQUIPMENT POWER UP	G	0	0	0	-	-	0	0	0	-	-3	
		M	0	0	-	+	+	+	+	+	0	+4	M, A, G
		A	0	0	0	-	-	0	0	0	+	-1	
	CAUTION & WARNING CHECK	G	0	0	0	-	-	0	-	-	-	-5	
		M	0	0	0	0	+	0	+	+	0	+3	M, A, G
		A	0	0	0	0	0	0	0	-	+	0	
	FUNCTIONAL HEALTH CHECK	G	0	0	0	-	-	0	0	-	-	-4	
		M	0	0	0	+	+	0	0	+	0	+3	M, A, G
		A	0	0	0	0	0	0	0	-	+	0	
	COMMAND LOAD VERIFICATION	G	0	0	0	-	0	0	0	0	-	-2	
		M	0	0	0	+	+	0	0	0	0	+2	M, A, G
		A	0	0	0	-	0	0	0	-	+	-1	
	EQUIPMENT CALIBRATION	G											
		M											
		A											
EXPERIMENT OPERATIONS	MONITOR (EQUIP/D&C C&W)	G	0	0	0	-	0	0	0	0	-	-2	
		M	-	0	0	+	+	+	0	0	0	+2	M, A, G
		A	0	0	0	0	-	0	0	0	+	0	
	MODE CHANGE	G	0	0	0	-	-	0	-	-	-	-5	
		M	0	0	0	+	+	0	+	0	0	+3	M, A, G
		A	0	0	0	0	-	0	0	-	+	-1	
	R/T DATA. ANAL	G											
		M											
		A											

TABLE 3-5 FUNCTIONAL ASSESSMENT - FARUV (cont'd)

ORBITAL ACTIVITAL			EQUIPMENT LOC.	INSTRUMENTATION	PHYSICAL CONFIG.	COMMLINK REQ.	OPERATIONAL FLEX	SAFETY	COMPUTER USAGE	SOFTWARE REQ.	SECURITY	FAR UV	
EXPERIMENT OPERATIONS (cont'd)	EQUIPMENT OPTIMIZATION	G	////	////	////	////	////	////	////	////	////	////	
		M	////	////	////	////	////	////	////	////	////	////	
		A	////	////	////	////	////	////	////	////	////	////	
	POINTING OPTIMIZATION	G	0	0	0	-	+	0	0	0	-	-1	
		M	0	-	0	+	-	0	0	-	0	-2	A, G, M
		A	0	0	0	-	+	0	0	0	+	+1	
	TARGET SELECTION	G	0	-	0	-	0	0	-	-	-	-5	
		M	0	0	0	+	+	0	+	0	0	+3	M, A, G
		A	0	-	0	-	-	0	-	-	+	-4	
	DATA MANAGEMENT	G	////	////	////	////	////	////	////	////			
		M	////	////	////	////	////	////	////	////			
		A	////	////	////	////	////	////	////	////			
	COMMAND INITIATION	G	0	0	0	-	0	0	0	0	-	-2	
		M	0	0	0	+	+	+	+	0	0	+4	M, G/A
		A	0	0	0	-	-	0	0	-	+	-2	
	EXP OPS VERIFICATION	G	0	0	0	-	0	0	0	0	-	-2	
		M	0	0	0	0	+	0	+	0	0	+2	M, A, G
		A	0	0	0	0	0	0	0	0	+	+1	
	GROUND CO-ORD	G	0	0	0	0	0	0	0	0	-	-1	
		M	0	0	0	0	+	0	0	0	0	+1	M/A, G
		A	0	0	0	0	0	0	0	0	+	+1	
	MANUAL PHOTOGRAPHY	G	////	////	////	////	////	////	////	////	////	////	
		M	////	////	////	////	////	////	////	////	////	////	
		A	////	////	////	////	////	////	////	////	////	////	
	EVENT ENABLE	G	////	////	////	////	////	////	////	////	////	////	
		M	////	////	////	////	////	////	////	////	////	////	
		A	////	////	////	////	////	////	////	////	////	////	
	SEQ/CONFIG VERIFICATION	G	0	0	0	-	0	0	0	0	-	-2	
		M	0	0	0	+	+	0	0	0	0	+2	M, A, G
		A	0	0	0	0	-	0	0	0	+	0	
	OPERATIONAL COMMENTARY	G	0	0	0	0	0	0	-	-	-	-2	
		M	0	0	0	+	0	0	0	0	0	+1	M, A, G
		A	0	0	0	0	0	0	-	-	+	-1	
	COMMAND EXECUTION	G	0	0	0	0	0	0	-	-	-	-3	
		M	0	0	0	+	+	0	0	0	0	+2	M, A, G
		A	0	0	0	+	0	0	0	-	+	+1	
	RMS ACTIVITIES	G	////	////	////	////	////	////	////	////	////	////	
		M	////	////	////	////	////	////	////	////	////	////	
		A	////	////	////	////	////	////	////	////	////	////	
	ELEVATION/ RETRACTION OPS	G	////	////	////	////	////	////	////	////	////	////	
		M	////	////	////	////	////	////	////	////	////	////	
		A	////	////	////	////	////	////	////	////	////	////	
	DEPLOY/JETT OPS	G	////	////	////	////	////	////	////	////	////	////	
		M	////	////	////	////	////	////	////	////	////	////	
		A	////	////	////	////	////	////	////	////	////	////	
POST OPERATIONS CONFIGURATION	EQUIP POWER DOWN	G	0	0	0	-	-	0	0	0	-	-3	
		M	0	0	-	+	+	+	+	+	0	+4	M, A, G
		A	0	0	0	-	-	0	0	0	+	-1	
	EQUIP SAFING/ RECONFIG	G	0	0	0	-	-	0	-	0	-	-2	
		M	0	0	0	+	+	0	+	+	0	+4	M, A, G
		A	0	0	0	0	0	0	0	0	+	+1	
	DATA ANNOTATION/ STORAGE	G	////	////	////	////	////	////	////	////	////	////	
		M	////	////	////	////	////	////	////	////	////	////	
		A	////	////	////	////	////	////	////	////	////	////	

TABLE 3-5 FUNCTIONAL ASSESSMENT - FARUV (cont'd)

	ORBITAL ACTIVITY		EQUIPMENT LOC.	INSTRUMENTATION	PHYSICAL CONFIG.	COMM.LINK REQ.	OPERATIONAL FLE	SAFETY	COMPUTER USAGE	SOFTWARE REQ.	SECURITY	FAR UV	
BRIEF	POST PASS DEBRIEF	G	0	0	0	0	0	0	0	0	-	-1	A, M/G
		M	0	0	0	-	0	0	0	0	0	-1	
		A	0	0	0	0	0	0	0	0	+	+1	
PRE LANDING PREPARATIONS	EQUIPMENT STORAGE	G	///	///	///	///	///	///	///	///	///	///	
		M	///	///	///	///	///	///	///	///	///	///	
		A	///	///	///	///	///	///	///	///	///	///	
	COMPLETE POWER DOWN/ SAFING	G	0	0	0	-	-	0	0	0	-	-3	M, A, G
		M	0	0	-	+	+	+	+	+	0	+4	
		A	0	0	0	0	0	0	0	0	+	+1	
	RESTRAINT/ PROTECTIVE DEVICE INSTAL	G	0	0	0	-	-	0	-	-	-	-5	M, A, G
		M	0	0	0	+	+	0	+	+	0	+4	
		A	0	0	0	0	-	0	0	-	+	-1	
	DATA STORAGE	G	///	///	///	///	///	///	///	///	///	///	
		M	///	///	///	///	///	///	///	///	///	///	
		A	///	///	///	///	///	///	///	///	///	///	
	C&W CHECK	G	0	0	0	-	-	0	-	-	-	-5	M, A, G
		M	0	0	0	0	+	0	+	+	0	+3	
		A	0	0	0	0	0	0	0	-	+	0	
EVA	PLANNED EVA	G	///	///	///	///	///	///	///	///	///	///	
		M	///	///	///	///	///	///	///	///	///	///	
		A	///	///	///	///	///	///	///	///	///	///	
	SPECIAL CONTINGENCY EVA	G	///	///	///	///	///	///	///	///	///	///	
		M	///	///	///	///	///	///	///	///	///	///	
		A	///	///	///	///	///	///	///	///	///	///	

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TABLE 3-6 FUNCTIONAL ASSESSMENT

	ORBITAL ACTIVITY		EQUIPMENT LOC.	INSTRUMENTATION	PHYSICAL CONFIG	COMM LINK REQ.	OPERATIONAL FLE	SAFETY	COMPUTER USAGE	SOFTWARE REQ.	SECURITY		SLED
POST LAUNCH ACTIVITIES	POST LAUNCH INSP	G	+	-	0	-	-	0	-	-	-	-5	M, A, G
		M	-	0	-	0	+	+	+	+	0	+2	
		A	+	-	0	-	0	-	-	-	+	-2	
	RESTRAINT/ PROTECTIVE DEVICE REMOVE	G	0	0	0	-	-	-	-	-	-	-6	M, A, G
		M	0	0	0	+	+	+	+	+	0	+5	
		A	0	0	0	-	-	-	0	-	+	-2	
	EXP STOWAGE REMOVAL	G											
		M											
		A											
	EQUIP/PANEL POST LAUNCH RECONFIG	G	0	0	0	-	0	0	-	-	-	-4	M, A, G
		M	0	0	0	+	+	+	+	+	0	+5	
		A	0	0	0	0	-	0	0	-	+	-1	
HEALTH & C & W VERIFICATION	CONFIG FOR INIT POWER UP	G	0	0	0	-	0	0	-	-	-	-4	M, A, G
		M	0	0	0	+	+	0	+	+	0	+4	
		A	0	0	0	0	-	0	0	-	+	-1	
	POWER ACTIVATING ENABLE	G	0	0	0	-	-	0	0	0	-	-3	M, A/G
		M	0	0	-	+	+	+	+	+	0	+4	
		A	0	0	0	-	-	0	0	0	+	-1	
	CAUTION WARNING VERIFICATION	G	0	0	0	-	-	0	-	-	-	-5	M, A, G
		M	0	0	0	0	+	0	+	+	0	+3	
		A	0	0	0	0	0	0	0	-	+	0	
	FUNCTIONAL HEALTH CHECK	G	0	0	0	-	-	0	-	-	-	-5	M, A, G
		M	-	+	-	+	+	0	+	+	0	+3	
		A	0	0	0	0	0	-	0	-	+	-1	
BRIEF	PREPASS BRIEFING	G	0	0	0	0	0	0	0	0	-	-1	A, G/M
		M	0	0	0	-	0	0	0	0	0	-1	
		A	0	0	0	0	0	0	0	0	+	+1	
PRE PASS ACTIVITIES	PREPASS EQUIP CONFIG	G	0	0	0	-	-	0	-	-	-	-5	M, A, G
		M	0	0	0	+	+	0	+	+	0	+4	
		A	0	0	0	0	0	0	0	-	+	0	
	EQUIPMENT POWER UP	G	0	0	0	-	-	0	0	0	-	-3	M, A, G
		M	0	0	-	+	+	+	+	+	0	+4	
		A	0	0	0	-	-	0	0	0	+	-1	
	CAUTION & WARNING CHECK	G	0	0	0	-	-	0	-	-	-	-5	M, A, G
		M	0	0	0	0	+	0	+	+	0	+3	
		A	0	0	0	0	0	0	0	-	+	0	
	FUNCTIONAL HEALTH CHECK	G	0	0	0	-	-	0	-	-	-	-5	M, A, G
		M	-	+	-	+	+	0	+	+	0	+3	
		A	0	0	0	0	0	-	0	-	+	-1	
	COMMAND LOAD VERIFICATION	G	0	0	0	-	0	0	0	0	-	-2	M, A, G
		M	0	0	0	+	+	0	0	0	0		
		A	0	0	0	-	0	0	0	-	+	-1	
	EQUIPMENT CALIBRATION	G											
		M											
		A											
EXPERIMENT OPERATIONS	MONITOR (EQUIP/D&C C&W)	G	0	0	0	-	0	0	0	0	-	-2	M, A, G
		M	-	0	0	+	+	+	0	0	0	+2	
		A	0	0	0	0	-	0	0	0	+	0	
	MODE CHANGE	G	0	0	0	-	-	0	-	-	-	-5	M, A, G
		M	0	0	-	+	+	0	+	0	0	+2	
		A	0	0	0	0	-	0	0	-	+	-1	
	R/T DATA ANAL	G											
		M											
		A											

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TABLE 3-6 FUNCTIONAL ASSESSMENT - SLED (cont'd)

	ORBITAL ACTIVITY		EQUIPMENT LOC.	INSTRUMENTATION	PHYSICAL CONFIG.	COMM LINK REQ	OPERATIONAL FLEX	SAFETY	COMPUTER USAGE	SOFTWARE REQ.	SECURITY		SLED
EXPERIMENT OPERATIONS (cont'd)	EQUIPMENT OPTIMIZATION	G											
		M											
		A											
	POINTING OPTIMIZATION	G	0	0	0	-	+	0	0	0	-	-1	
		M	0	-	0	+	-	0	0	-	0	-2	A, G, M
		A	0	0	0	-	+	0	0	0	+	+1	
	TARGET SELECTION	G											
		M											
		A											
	DATA MANAGEMENT	G	0	0	0	-	0	0	0	0	-	-2	
		M	0	0	0	0	0	0	-	-	0	-2	A, M/G
		A	0	0	0	+	0	0	+	0	+	+3	
	COMMAND INITIATION	G	0	0	0	-	0	0	-	0	-	-3	
		M	0	-	0	0	+	+	0	0	0	+2	M/A, G
		A	0	0	0	0	-	0	+	+	+	+2	
	EXP OPS VERIFICATION	G	0	0	0	-	0	0	0	0	-	-2	
		M	0	0	-	0	+	+	+	+	0	+3	M, A, G
		A	0	0	0	0	0	0	0	0	+	+1	
	GROUND CO-ORD	G	0	0	0	0	0	0	0	0	-	-1	
		M	0	0	0	0	+	0	0	+	0	+2	M, A, G
		A	0	0	0	0	0	0	0	0	+	+1	
	MANUAL PHOTOGRAPHY	G											
		M											
		A											
	EVENT ENABLE	G	0	0	0	-	0	0	0	0	-	-2	
		M	0	+	0	0	+	+	0	+	0	+4	M, A, G
		A	0	0	0	0	0	-	0	0	+	0	
	SEQ/CONFIG VERIFICATION	G	0	0	0	-	0	0	-	-	-	-4	
		M	-	0	0	+	+	+	+	+	0	+4	M, A, G
		A	0	0	0	0	0	0	0	-	+	0	
	OPERATIONAL COMMENTARY	G											
		M											
		A											
	COMMAND EXECUTION	G	0	0	0	-	0	0	0	-	-	-3	
		M	0	0	0	+	+	+	+	+	0	+5	M, A, G
		A	0	0	0	+	-	0	+	-	+	+1	
	RMS ACTIVITIES	G	0	-	-	-	-	0	-	-	-	-7	
		M	0	+	+	+	+	+	+	+	0	+7	M, A, G
		A	0	-	-	0	-	-	-	-	+	-5	
	ELEVATION/ RETRACTION OPS	G	0	0	0	-	-	0	-	-	-	-2	
		M	0	0	0	+	+	+	+	+	0	+5	M, A/G
		A	0	0	0	0	-	-	0	-	+	-2	
	DEPLOY/JETT OPS	G	0	-	0	-	0	0	-	-	-	-5	
		M	0	0	0	+	+	+	+	+	0	+5	M, A, G
		A	0	-	0	-	-	-	0	-	+	-4	
POST OPERATIONS CONFIGURATION	EQUIP POWER DOWN	G	0	0	0	-	-	0	0	0	-	-3	
		M	0	0	-	+	+	+	+	+	0	+4	M, A, G
		A	0	0	0	-	-	0	0	0	+	-1	
	EQUIP SAFING/ RECONFIG	G	0	0	0	-	0	0	-	-	-	-4	
		M	0	0	0	0	+	0	+	+	0	+3	M, A, G
		A	0	0	0	0	0	0	0	-	+	0	
	DATA ANNOTATION/ STORAGE	G											
		M											
		A											

TABLE 3-6 FUNCTIONAL ASSESSMENT - SLED (cont'd)

	ORBITAL ACTIVITY		EQUIPMENT LOC.	INSTRUMENTATION	PHYSICAL CONFIG.	COMM LINK REQ.	OPERATIONAL FLEX	SAFETY	COMPUTER USAGE	SOFTWARE REQ.	SECURITY		SLED
BRIEF	POST PASS DEBRIEF	G	0	0	0	0	0	0	0	0	-	-1	A, M/G
		M	0	0	0	-	0	0	0	0	0	-1	
		A	0	0	0	0	0	0	0	0	+	+1	
PRE LANDING PREPARATIONS	EQUIPMENT STORAGE	G											
		M											
		A											
	COMPLETE POWER DOWN/ SAFING	G	0	0	0	-	0	0	0	0	-	-2	M, A, G
		M	0	0	-	+	+	0	+	+	0	+3	
		A	0	0	0	0	0	0	0	0	+	+1	
	RESTRAINT/ PROTECTIVE DEVICE INSTAL	G	0	0	0	-	-	-	-	-	-	-6	M, A, G
		M	0	0	0	+	+	+	+	+	0	+5	
		A	0	0	0	-	-	-	0	-	+	-3	
	DATA STORAGE	G											
		M											
		A											
	C&W CHECK	G	0	0	0	-	-	0	-	-	-	-5	M, A, G
		M	0	0	0	0	+	0	+	+	0	+3	
		A	0	0	0	0	0	0	0	-	+	0	
EVA	PLANNED EVA	G											
		M											
		A											
	SPECIAL CONTINGENCY EVA	G											
		M											
		A											

TABLE 3-7 FUNCTIONAL ASSESSMENT - SEXTANT

	ORBITAL ACTIVITY		EQUIPMENT LOC.	INSTRUMENTATION	PHYSICAL CONFIG.	COMMLINK REQ.	OPERATIONAL FLEX.	SAFETY	COMPUTER USAGE	SOFTWARE REQ.	SECURITY		SEXTANT
POST LAUNCH ACTIVITIES	POST LAUNCH INSP	G	+	0	0	-	0	0	0	-	-	-2	M, A, G
		M	-	0	0	+	+	0	0	+	0	+2	
		A	+	0	0	0	0	0	0	-	-	+1	
	RESTRAINT/ PROTECTIVE DEVICE REMOVE	G	0	0	0	-	0	0	-	-	-	-4	A, M, G
		M	0	0	-	0	+	0	0	-	0	-1	
		A	0	0	0	-	0	0	0	0	+	0	
	EXP STOWAGE REMOVAL	G											
		M											
		A											
	EQUIP/PANEL POST LAUNCH RECONFIG	G											
		M											
		A											
HEALTH & C & W VERIFICATION	CONFIG FOR INIT POWER UP	G	0	0	0	-	0	0	-	0	-	-3	M, A, G
		M	0	0	0	0	+	0	0	+	0	+2	
		A	0	0	0	0	0	0	0	0	+	+1	
	POWER ACTIVATING ENABLE	G											
		M											
		A											
	CAUTION WARNING VERIFICATION	G											
		M											
		A											
	FUNCTIONAL HEALTH CHECK	G	0	0	0	-	0	0	0	0	-	-2	A, M, G
		M	0	0	0	0	+	0	0	0	0	+1	
		A	0	0	0	0	0	0	+	0	+	+2	
BRIEF	PREPASS BRIEFING	G	0	0	0	0	0	0	0	0	-	-1	A, M/G
		M	0	0	0	-	0	0	0	0	0	-1	
		A	0	0	0	0	0	0	0	0	+	+1	
PRE PASS ACTIVITIES	PREPASS EQUIP CONFIG	G											
		M											
		A											
	EQUIPMENT POWER UP	G	0	0	0	-	-	0	0	0	-	-3	M, A, G
		M	0	0	0	+	+	0	0	0	0	+2	
		A	0	0	0	-	-	0	0	+	+	0	
	CAUTION & WARNING CHECK	G											
		M											
		A											
	FUNCTIONAL HEALTH CHECK	G	0	0	0	-	0	0	0	0	-	-2	A, M, G
		M	0	0	0	0	+	0	0	0	0	+1	
		A	0	0	0	0	0	0	+	0	+	+2	
	COMMAND LOAD VERIFICATION	G	0	0	0	0	0	0	0	0	-	-1	M, A, G
		M	0	0	0	+	+	0	0	0	0	+2	
		A	0	0	0	0	0	0	+	-	+	+1	
	EQUIPMENT CALIBRATION	G											
		M											
		A											
EXPERIMENT OPERATIONS	MONITOR (EQUIP/D&C C&W)	G	0	0	0	-	0	0	0	0	-	-2	M, A, G
		M	-	0	0	+	+	0	0	0	0	+1	
		A	0	0	0	0	-	0	0	0	+	0	
	MODE CHANGE	G											
		M											
		A											
	R/T DATA ANAL	G											
		M											
		A											

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TABLE 3-7 FUNCTIONAL ASSESSMENT - SEXTANT (cont'd)

	ORBITAL ACTIVITY		EQUIPMENT LOC.	INSTRUMENTATION	PHYSICAL CONFIG	COMM. LINK REQ.	OPERATIONAL FLE	SAFETY	COMPUTER USAGE	SOFTWARE REQ.	SECURITY		SEXTANT
EXPERIMENT OPERATIONS (cont'd)	EQUIPMENT OPTIMIZATION	G	////	////	////	////	////	////	////	////	////	////	
		M	////	////	////	////	////	////	////	////	////	////	
		A	////	////	////	////	////	////	////	////	////	////	
	POINTING OPTIMIZATION	G	////	////	////	////	////	////	////	////	////	////	
		M	////	////	////	////	////	////	////	////	////	////	
		A	////	////	////	////	////	////	////	////	////	////	
	TARGET SELECTION	G	0	0	0	0	+	0	0	0	-	0	A, M/G
		M	0	0	0	+	0	0	0	-	0	0	
		A	0	0	0	0	0	0	+	0	+	+2	
	DATA MANAGEMENT	G	////	////	////	////	////	////	////	////	////	////	
		M	////	////	////	////	////	////	////	////	////	////	
		A	////	////	////	////	////	////	////	////	////	////	
	COMMAND INITIATION	G	0	0	0	-	0	0	0	0	-	-2	M/A, G
		M	0	0	0	0	0	0	0	-	0	-1	
		A	0	0	0	-	-	0	0	0	+	-1	
	EXP OPS VERIFICATION	G	0	0	0	0	0	0	0	0	-	-1	M/A, G
		M	-	0	0	+	+	0	0	0	0	+1	
		A	0	0	0	0	0	0	0	0	+	+1	
	GROUND CO-ORD	G	0	0	0	0	+	0	0	0	-	0	A, G, M
		M	0	0	0	0	0	0	0	-	0	-1	
		A	0	0	0	0	+	0	0	0	+	+2	
	MANUAL PHOTOGRAPHY	G	////	////	////	////	////	////	////	////	////	////	
		M	////	////	////	////	////	////	////	////	////	////	
		A	////	////	////	////	////	////	////	////	////	////	
	EVENT ENABLE	G	////	////	////	////	////	////	////	////	////	////	
		M	////	////	////	////	////	////	////	////	////	////	
		A	////	////	////	////	////	////	////	////	////	////	
	SEQ/CONFIG VERIFICATION	G	0	0	0	-	0	0	0	0	-	-2	M/A, G
		M	0	0	0	+	+	0	0	-	0	+1	
		A	0	0	0	0	0	0	0	0	+	+1	
	OPERATIONAL COMMENTARY	G	////	////	////	////	////	////	////	////	////	////	
		M	////	////	////	////	////	////	////	////	////	////	
		A	////	////	////	////	////	////	////	////	////	////	
	COMMAND EXECUTION	G	0	0	0	0	0	0	0	0	-	-1	M, A, G
		M	0	0	0	+	+	0	0	-	0	+1	
		A	0	0	0	0	-	0	0	0	+	0	
	RMS ACTIVITIES	G	////	////	////	////	////	////	////	////	////	////	
		M	////	////	////	////	////	////	////	////	////	////	
		A	////	////	////	////	////	////	////	////	////	////	
	ELEVATION/ RETRACTION OPS	G	////	////	////	////	////	////	////	////	////	////	
		M	////	////	////	////	////	////	////	////	////	////	
		A	////	////	////	////	////	////	////	////	////	////	
	DEPLOY/JETT OPS	G	////	////	////	////	////	////	////	////	////	////	
		M	////	////	////	////	////	////	////	////	////	////	
		A	////	////	////	////	////	////	////	////	////	////	
POST OPERATIONS CONFIGURATION	EQUIP POWER DOWN	G	0	0	0	-	-	0	0	0	-	-3	M, A, G
		M	0	0	0	+	+	0	0	0	0	+2	
		A	0	0	0	-	-	0	0	+	+	0	
	EQUIP SAFING/ RECONFIG	G	////	////	////	////	////	////	////	////	////	////	
		M	////	////	////	////	////	////	////	////	////	////	
		A	////	////	////	////	////	////	////	////	////	////	
	DATA ANNOTATION/ STORAGE	G	////	////	////	////	////	////	////	////	////	////	
		M	////	////	////	////	////	////	////	////	////	////	
		A	////	////	////	////	////	////	////	////	////	////	

TABLE 3-7 FUNCTIONAL ASSESSMENT - SEXTANT (cont'd)

	ORBITAL ACTIVITY		EQUIPMENT LOC.	INSTRUMENTATION	PHYSICAL CONFIG.	COMM LINK REQ.	OPERATIONAL FLEX	SAFETY	COMPUTER USAGE	SOFTWARE REQ.	SECURITY		SEXTANT
BRIEF	POST PASS DEBRIEF	G											
		M											
		A											
PRE LANDING PREPARATIONS	EQUIPMENT STORAGE	G											
		M											
		A											
	COMPLETE POWER DOWN/ SAFING	G											
		M											
		A											
	RESTRAINT/ PROTECTIVE DEVICE INSTAL	G	0	0	0	-	0	0	-	-	-	-4	A, M, G
		M	0.	0	-	0	+	0	0	-	0	-1	
		A	0	0	0	-	0	0	0	-0	+	0	
	DATA STORAGE	G											
		M											
		A											
	C&W CHECK	G											
		M											
		A											
EVA	PLANNED EVA	G											
		M											
		A											
	SPECIAL CONTINGENCY EVA	G											
		M											
		A											

TABLE 3-8 FUNCTIONAL ASSESSMENT - PRAT

	ORBITAL ACTIVITY		EQUIPMENT LOC.	INSTRUMENTATION	PHYSICAL CONFIG	COMM.LINK REQ.	OPERATIONAL FLE	SAFETY	COMPUTER USAGE	SOFTWARE REQ.	SECURITY		PRAT
POST LAUNCH ACTIVITIES	POST LAUNCH INSP	G	+	-	0	-	-	0	-	-	-	-5	M, A, G
		M	-	0	-	0	+	+	+	+	0	+2	
		A	+	-	0	0	-	0	-	-	+	-2	
	RESTRAINT/ PROTECTIVE DEVICE REMOVE	G	0	0	0	-	-	-	-	-	-	-6	M, A, G
		M	0	0	0	+	+	+	+	+	0	+5	
		A	0	0	0	-	-	-	-	-	+	-3	
	EXP STOWAGE REMOVAL	G	-	0	-	-	-	0	-	-	-	-7	M, A/G
		M	+	0	+	+	+	0	+	+	0	+6	
		A	-	0	-	-	-	0	-	-	+	-5	
	EQUIP/PANEL POST LAUNCH RECONFIG	G	0	0	0	-	0	0	-	-	-	-4	M, A, G
		M	0	0	0	+	+	+	+	+	0	+5	
		A	0	0	0	0	-	0	0	-	+	-1	
HEALTH & C & W VERIFICATION	CONFIG FOR INIT POWER UP	G	0	0	0	-	0	0	-	-	-	-4	M, A, G
		M	0	0	0	+	+	0	+	+	0	+1	
		A	0	0	0	0	-	0	0	-	+	-1	
	POWER ACTIVATING ENABLE	G	0	0	0	-	-	0	0	0	-	-3	M, A/G
		M	0	0	-	+	+	+	+	+	0	+4	
		A	0	0	0	-	-	0	0	0	+	-1	
	CAUTION WARNING VERIFICATION	G	0	0	0	-	-	0	-	-	-	-5	M, A, G
		M	0	0	0	0	+	0	+	+	0	+3	
		A	0	0	0	0	0	0	0	-	+	0	
	FUNCTIONAL HEALTH CHECK	G	0	0	0	-	-	0	-	-	-	-5	M, A, G
		M	-	+	-	+	+	0	+	+	0	+3	
		A	0	0	0	0	0	-	0	-	+	-1	
BRIEF	PREPASS BRIEFING	G	0	0	0	0	0	0	0	0	-	-1	A, M/G
		M	0	0	0	-	0	0	0	0	0	-1	
		A	0	0	0	0	0	0	0	0	+	+1	
PRE PASS ACTIVITIES	PREPASS EQUIP CONFIG	G	0	0	-	-	-	0	-	-	-	-6	M, A, G
		M	+	+	+	+	+	-	+	+	0	+7	
		A	0	0	-	0	-	0	0	-	+	-2	
	EQUIPMENT POWER UP	G	0	0	0	-	-	0	0	0	-	-3	M, A, G
		M	0	0	-	+	+	+	+	+	0	+4	
		A	0	0	0	-	-	0	0	0	+	-1	
	CAUTION & WARNING CHECK	G	0	0	0	-	-	0	-	-	-	-5	M, A, G
		M	0	0	0	0	+	0	+	+	0	+3	
		A	0	0	0	0	0	0	0	-	+	0	
	FUNCTIONAL HEALTH CHECK	G	0	-	0	-	-	0	-	-	-	-6	M, A, G
		M	-	+	0	+	+	0	+	+	0	+4	
		A	0	-	0	0	0	-	0	-	+	-2	
	COMMAND LOAD VERIFICATION	G	0	0	0	-	-	0	-	-	-	-5	M, A, G
		M	0	0	0	+	+	0	+	+	0	+4	
		A	0	0	0	-	-	0	0	-	+	-2	
	EQUIPMENT CALIBRATION	G	0	0	0	-	0	0	-	-	-	-3	M, A, G
		M	-	0	0	+	+	0	+	+	0	+3	
		A	0	0	0	0	0	0	0	-	+	0	
EXPERIMENT OPERATIONS	MONITOR (EQUIP/D&C C&W)	G	0	0	0	-	0	0	0	0	-	-2	M, A/G
		M	-	0	0	+	+	+	0	0	0	+2	
		A	0	0	0	0	-	0	0	0	+	0	
	MODE CHANGE	G	0	0	0	-	-	0	-	-	-	-5	M, A, G
		M	0	0	-	+	+	0	+	0	0	+2	
		A	0	0	0	0	-	0	0	-	+	-1	
	R/T DATA ANAL	G	0	0	0	-	0	0	0	0	-	-2	M, A, G
		M	0	0	+	+	+	0	0	+	0	+4	
		A	0	0	0	0	0	0	0	0	+	+1	

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TABLE 3-8 FUNCTIONAL ASSESSMENT - PRAT (cont'd)

ORBITAL ACTIVITY			EQUIPMENT LOC.	INSTRUMENTATION	PHYSICAL CONFIG.	COMM LINK REQ.	OPERATIONAL FLEX	SAFETY	COMPUTER USAGE	SOFTWARE REQ.	SECURITY		PRAT
EXPERIMENT OPERATIONS (cont'd)	EQUIPMENT OPTIMIZATION	G	////	////	////	////	////	////	////	////	////	////	
		M	////	////	////	////	////	////	////	////	////	////	
		A	////	////	////	////	////	////	////	////	////	////	
	POINTING OPTIMIZATION	G	////	////	////	////	////	////	////	////	////	////	
		M	////	////	////	////	////	////	////	////	////	////	
		A	////	////	////	////	////	////	////	////	////	////	
	TARGET SELECTION	G	////	////	////	////	////	////	////	////	////	////	
		M	////	////	////	////	////	////	////	////	////	////	
		A	////	////	////	////	////	////	////	////	////	////	
	DATA MANAGEMENT	G	0	0	0	-	-	0	-	-	-	-2	M, A, G
		M	-	+	0	+	+	0	+	+	0	+4	
		A	0	0	0	0	-	0	0	-	+	-1	
	COMMAND INITIATION	G	0	0	0	-	-	0	0	-	-	-4	M, A, G
		M	0	0	+	+	+	+	0	+	0	+5	
		A	0	0	0	0	-	0	0	-	+	-1	
	EXP OPS VERIFICATION	G	+	-	0	-	0	0	-	-	-	-4	M, A, G
		M	-	+	+	+	+	0	+	+	0	+5	
		A	+	-	0	0	0	0	-	-	+	-1	
	GROUND CO-ORD	G	////	////	////	////	////	////	////	////	////	////	
		M	////	////	////	////	////	////	////	////	////	////	
		A	////	////	////	////	////	////	////	////	////	////	
	MANUAL PHOTOGRAPHY	G	0	0	0	-	-	0	-	-	-	-5	M, A, G
		M	0	+	+	+	+	0	+	+	0	+6	
		A	0	0	0	-	-	0	-	-	+	-3	
	EVENT ENABLE	G	0	0	0	-	0	0	0	0	-	-2	M, A, G
		M	0	+	0	0	+	+	0	+	0	+4	
		A	0	0	0	0	0	-	0	0	+	0	
	SEQ/CONFIG VERIFICATION	G	0	0	0	-	0	0	-	-	-	-4	M, A, G
		M	-	0	0	+	+	+	+	+	-	+4	
		A	0	0	0	0	0	0	0	-	+	0	
	OPERATIONAL COMMENTARY	G	0	0	0	-	0	0	0	-	-	-3	M, A/G
		M	0	0	0	+	+	0	0	0	0	+2	
		A	0	0	0	-	0	0	0	-	+	-1	
	COMMAND EXECUTION	G	0	0	0	-	-	0	0	-	-	-4	M, A, G
		M	-	0	0	+	+	+	+	+	0	+4	
		A	0	0	0	0	-	0	+	-	+	0	
	RMS ACTIVITIES	G	0	-	-	-	-	0	-	-	-	-7	M, A, G
		M	0	+	+	+	+	+	+	+	0	+7	
		A	0	-	-	0	-	-	-	-	+	-5	
	ELEVATION/ RETRACTION OPS	G	0	0	0	-	-	0	-	-	-	-5	M, A, G
		M	0	0	0	+	+	+	+	+	0	+5	
		A	0	0	0	0	-	-	0	-	+	-2	
	DEPLOY/JETT OPS	G	0	-	0	-	0	0	-	-	-	-5	M, A, G
		M	0	0	0	+	+	+	+	+	0	+5	
		A	0	-	0	-	-	-	0	-	+	-4	
POST OPERATIONS CONFIGURATION	EQUIP POWER DOWN	G	0	0	0	-	-	0	0	2	-	-3	M, A, G
		M	0	0	-	+	+	+	+	+4	0	+4	
		A	0	0	0	-	-	0	0	-2	+	-1	
	EQUIP SAFING/ RECONFIG	G	0	0	0	-	0	0	-	-3	-	-4	M, A, G
		M	0	0	0	0	+	0	+	+3	0	+3	
		A	0	0	0	0	0	0	0	-1	+	0	
	DATA ANNOTATION/ STORAGE	G	0	0	-	-	0	0	0	-3	-	-4	M, A, G
		M	0	+	+	+	+	0	0	+5	0	+5	
		A	0	0	-	0	0	0	0	-2	+	-1	

TABLE 3-8 FUNCTIONAL ASSESSMENT - PRAT (cont'd)

	ORBITAL ACTIVITY		EQUIPMENT LOC.	INSTRUMENTATION	PHYSICAL CONFIG.	COMM LINK REQ.	OPERATIONAL FLEX	SAFETY	COMPUTER USAGE	SOFTWARE REQ.	SECURITY	PRAT	
BRIEF	POST PASS DEBRIEF	G	0	0	0	0	0	0	0	0	-	-1	A, M/G
		M	0	0	0	-	0	0	0	0	0	-1	
		A	0	0	0	0	0	0	0	0	+	+1	
PRE LANDING PREPARATIONS	EQUIPMENT STORAGE	G	-	0	-	-	-	0	-	-	-	-7	M, A, G
		M	+	0	+	+	+	0	+	+	0	+6	
		A	-	0	-	-	-	0	-	-	+	-5	
	COMPLETE POWER DOWN/ SAFING	G	0	0	0	-	0	0	0	0	-	-2	M, A, G
		M	0	0	-	+	+	0	+	+	0	+3	
		A	0	0	0	0	0	0	0	0	+	+1	
	RESTRAINT/ PROTECTIVE DEVICE INSTAL	G	0	0	0	-	-	-	-	-	-	-6	M, A, G
		M	0	0	0	+	+	+	+	+	0	+5	
		A	0	0	0	-	-	-	0	-	+	-3	
	DATA STORAGE	G	0	0	-	-	0	0	0	-	-	-4	M, A, G
		M	0	+	+	+	+	0	0	+	0	+5	
		A	0	0	-	0	0	0	0	-	+	-1	
	C&W CHECK	G	0	0	0	-	-	0	-	-	-	-5	M, A, G
		M	0	0	0	0	+	0	+	+	0	+3	
		A	0	0	0	0	0	0	0	-	+	0	
EVA	PLANNED EVA	G	0	0	-	-	-	0	-	-	-	-6	M, A, G
		M	0	0	+	+	+	+	+	+	0	+6	
		A	0	0	-	-	-	0	-	-	+	-4	
	SPECIAL CONTINGENCY EVA	G	-	0	-	-	-	0	-	-	-	-7	M, A, G
		M	+	0	+	+	+	+	+	+	0	+7	
		A	-	0	-	-	-	0	-	-	+	-5	

TABLE 3-9 FUNCTIONAL ASSESSMENT - OCMD

	ORBITAL ACTIVITY		EQUIPMENT LOC.	INSTRUMENTATION	PHYSICAL CONFIG.	COMM LINK REQ.	OPERATIONAL FLEX.	SAFETY	COMPUTER USAGE	SOFTWARE REQ.	SECURITY		OCMD
POST LAUNCH ACTIVITIES	POST LAUNCH INSP	G	+	-	0	-	-	0	-	-	-	-5	M, A, G
		M	-	0	-	0	+	+	+	+	0	+2	
		A	+	-	0	0	-	0	-	-	+	-2	
	RESTRAINT/ PROTECTIVE DEVICE REMOVE	G	0	0	0	-	-	-	-	-	-	-6	M, A, G
		M	0	0	0	+	+	+	+	+	0	+5	
		A	0	0	0	-	-	-	0	-	+	-3	
	EXP STOWAGE REMOVAL	G											
		M											
		A											
	EQUIP/PANEL POST LAUNCH RECONFIG	G	0	0	0	-	0	0	-	-	-	-4	M, A, G
		M	0	0	0	+	+	+	+	+	0	+5	
		A	0	0	0	0	-	0	0	-	+	-1	
HEALTH & C & W VERIFICATION	CONFIG FOR INIT POWER UP	G	0	0	0	-	0	0	-	-	-	-4	M, A, G
		M	0	0	0	+	+	0	+	+	0	+4	
		A	0	0	0	0	-	0	0	-	+	-1	
	POWER ACTIVATING ENABLE	G	0	0	0	-	-	0	0	0	-	-3	M, A, G
		M	0	0	-	+	+	+	+	+	0	+4	
		A	0	0	0	-	-	0	0	0	+	-1	
	CAUTION WARNING VERIFICATION	G	0	0	0	-	-	0	-	-	-	-5	M, A, G
		M	0	0	0	0	+	0	+	+	0	+3	
		A	0	0	0	0	0	0	0	-	+	0	
	FUNCTIONAL HEALTH CHECK	G	0	0	0	-	-	0	-	-	-	-5	M, A, G
		M	-	+	-	+	+	0	+	+	0	+3	
		A	0	0	0	0	0	-	0	-	+	-1	
BRIEF	PREPASS BRIEFING	G											
		M											
		A											
PRE PASS ACTIVITIES	PREPASS EQUIP CONFIG	G	0	0	0	-	-	0	-	-	-	-5	M, A, G
		M	0	0	0	+	+	+	+	+	0	+5	
		A	0	0	0	0	0	0	0	-	+	0	
	EQUIPMENT POWER UP	G	0	0	0	-	-	0	0	0	-	-3	M, A, G
		M	0	0	-	+	+	+	+	+	0	+4	
		A	0	0	0	-	-	0	0	0	+	-1	
	CAUTION & WARNING CHECK	G											
		M											
		A											
	FUNCTIONAL HEALTH CHECK	G	0	0	0	-	-	0	-	-	-	-5	M, A, G
		M	0	0	0	+	+	0	+	+	0	+3	
		A	0	0	0	0	0	-	0	-	+	-1	
	COMMAND LOAD VERIFICATION	G	0	0	0	0	0	0	0	0	-	-1	A, G, M
		M	0	0	0	0	-	0	0	-	0	-2	
		A	0	0	0	0	0	0	0	0	+	+1	
	EQUIPMENT CALIBRATION	G	0	0	0	-	0	0	0	0	-	-2	A, M, G
		M	0	0	-	+	+	0	0	0	0	+1	
		A	0	0	0	0	0	0	+	0	+	+2	
EXPERIMENT OPERATIONS	MONITOR (EQUIP/D&C C&W)	G	0	0	0	-	0	0	0	0	-	-2	M, A, G
		M	-	0	0	+	+	+	0	0	0	+2	
		A	0	0	0	0	-	0	0	0	+	0	
	MODE CHANGE	G											
		M											
		A											
	R/T DATA ANAL	G											
		M											
		A											

TABLE 3-9 FUNCTIONAL ASSESSMENT - OCMD (cont'd)

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ORBITAL ACTIVITY			EQUIPMENT LOC.	INSTRUMENTATION	PHYSICAL CONFIG.	COMM.LINK REQ.	OPERATIONAL FLEX	SAFETY	COMPUTER USAGE	SOFTWARE REQ.	SECURITY	OCMD	
EXPERIMENT OPERATIONS (cont'd)	EQUIPMENT OPTIMIZATION	G	0	0	0	-	0	0	0	-	-	-3	M, A, G
		M	0	0	0	+	+	0	+	+	0	+4	
		A	0	0	0	0	0	0	0	-	+	0	
	POINTING OPTIMIZATION	G	////	////	////	////	////	////	////	////	////	////	
		M	////	////	////	////	////	////	////	////	////	////	
		A	////	////	////	////	////	////	////	////	////	////	
	TARGET SELECTION	G	////	////	////	////	////	////	////	////	////	////	
		M	////	////	////	////	////	////	////	////	////	////	
		A	////	////	////	////	////	////	////	////	////	////	
	DATA MANAGEMENT	G	////	////	////	////	////	////	////	////	////	////	
		M	////	////	////	////	////	////	////	////	////	////	
		A	////	////	////	////	////	////	////	////	////	////	
	COMMAND INITIATION	G	0	0	0	0	0	0	0	0	-	-1	A, M/G
		M	0	0	-	+	0	0	0	-	0	-1	
		A	0	0	0	0	0	0	0	0	+	+1	
	EXP OPS VERIFICATION	G	0	0	0	0	0	0	0	0	-	-1	A, M, G
		M	0	0	0	0	0	+	0	-	0	0	
		A	0	0	0	0	0	0	0	0	+	+1	
	GROUND CO-ORD	G	0	0	0	0	0	0	0	0	-	-1	A, M, G
		M	0	0	0	0	0	0	0	0	0	0	
		A	0	0	0	0	0	0	0	0	+	+1	
	MANUAL PHOTOGRAPHY	G	////	////	////	////	////	////	////	////	////	////	
		M	////	////	////	////	////	////	////	////	////	////	
		A	////	////	////	////	////	////	////	////	////	////	
	EVENT ENABLE	G	0	0	0	-	0	0	0	0	-	-2	M, A, G
		M	0	+	0	0	+	+	0	+	0	+4	
		A	0	0	0	0	0	-	0	0	+	0	
	SEQ/CONFIG VERIFICATION	G	0	0	0	-	0	0	-	-	-	-4	M, A, G
		M	-	0	0	+	+	+	+	+	0	+4	
		A	0	0	0	0	0	0	0	-	+	0	
	OPERATIONAL COMMENTARY	G	////	////	////	////	////	////	////	////	////	////	
		M	////	////	////	////	////	////	////	////	////	////	
		A	////	////	////	////	////	////	////	////	////	////	
	COMMAND EXECUTION	G	0	0	0	0	0	0	-	-	-	-3	M, A, G
		M	0	0	0	+	+	0	0	0	0	+2	
		A	0	0	0	+	0	0	0	-	+	+1	
	RMS ACTIVITIES	G	0	-	-	-	-	0	-	-	-	-7	M, A, G
		M	0	+	+	+	+	+	+	+	0	+7	
		A	0	-	-	0	-	-	-	-	+	-5	
	ELEVATION/ RETRACTION OPS	G	////	////	////	////	////	////	////	////	////	////	
		M	////	////	////	////	////	////	////	////	////	////	
		A	////	////	////	////	////	////	////	////	////	////	
	DEPLOY/JETT OPS	G	////	////	////	////	////	////	////	////	////	////	
		M	////	////	////	////	////	////	////	////	////	////	
		A	////	////	////	////	////	////	////	////	////	////	
POST OPERATIONS CONFIGURATION	EQUIP POWER DOWN	G	0	0	0	-	-	0	0	0	-	-3	M, A, G
		M	0	0	-	+	+	+	+	+	0	+4	
		A	0	0	0	-	-	0	0	0	+	-1	
	EQUIP SAFING/ RECONFIG	G	0	0	0	-	-	0	-	-	-	-5	M, A, G
		M	0	0	0	+	+	+	+	+	0	+5	
		A	0	0	0	0	0	0	0	0	+	+1	
	DATA ANNOTATION/ STORAGE	G	////	////	////	////	////	////	////	////	////	////	
		M	////	////	////	////	////	////	////	////	////	////	
		A	////	////	////	////	////	////	////	////	////	////	

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TABLE 3-9 FUNCTIONAL ASSESSMENT - OCMD (cont'd)

	ORBITAL ACTIVITY		EQUIPMENT LOC.	INSTRUMENTATION	PHYSICAL CONFIG.	COMM. LINK REQ.	OPERATIONAL FLEX	SAFETY	COMPUTER USAGE	SOFTWARE REQ.	SECURITY	OCMD	
BRIEF	POST PASS DEBRIEF	G	0	0	0	0	0	0	0	0	-	-1	A, M/G
		M	0	0	0	-	0	0	0	0	0	-1	
		A	0	0	0	0	0	0	0	0	+	+1	
PRE LANDING PREPARATIONS	EQUIPMENT STORAGE	G											
		M											
		A											
	COMPLETE POWER DOWN/ SAFING	G	0	0	0	-	-	0	0	0	-	-3	M, A, G
		M	0	0	-	+	+	+	+	+	0	+4	
		A	0	0	0	-	-	0	0	0	+	-1	
	RESTRAINT/ PROTECTIVE DEVICE INSTAL	G	0	0	0	-	-	-	-	-	-	-6	M, A, G
		M	0	0	0	+	+	+	+	+	0	+5	
		A	0	0	0	-	-	-	0	-	+	-3	
	DATA STORAGE	G											
		M											
		A											
	C&W CHECK	G	0	0	0	-	-	0	-	-	-	-5	M, A, G
		M	0	0	0	0	+	0	+	+	0	+3	
		A	0	0	0	0	0	0	0	-	+	0	
EVA	PLANNED EVA	G											
		M											
		A											
	SPECIAL CONTINGENCY EVA	G											
		M											
		A											

3.6 MANNED ACTIVITY DEFINITION

The results of the manned activities for the five baseline experiments developed in Section 3.5 are summarized in Table 3 -10. Each activity is coded with a "G" indicating a ground activity,"M" indicating an on orbit crew activity and an "A" indicating an automated activity. The order of preference is from top to bottom for each activity.

Of the 44 identified operational activities, 34 indicate a preference for on-board crew performance which could, however, be altered by automated techniques as discussed in Section 3.5. Included in these 34 activities are all the activities identified for the post launch, health and C&W verification, post operations configuration, pre-landing preparations and EVA phases of on orbit operations.

In general, the summary of activities indicates that most pre and post experiment operations phase activities are candidates for on-orbit crew functions. The experiment operations phase, however, provides a mix of implementation preferences for 5 of the 18 activities identified which are highly dependent on the payload mission objectives, configuration and payload element interactions, i.e., cooperative ground sites, targets, detached free flyers, etc. Within these 5 implementation mix areas, no trends are evident to provide general guidelines to establish manned interface functions. As a result, it is recommended that the experiment operations phase of any candidate payload be assessed independently to determine its peculiar manned interface functions, and that this assessment be performed with detailed knowledge of the payload objectives, configuration and essential functional flow diagrams.

TABLE 3-10

ORBITAL MANNED ACTIVITY SUMMARY

		FAR UV	SLED	SEXTANT	PRAT	OCMO			SUMMARY	REMARKS
POST LAUNCH ACTIVITIES	POST LAUNCH INSP	M A G	M A G	M A G	M A G	M A G			M A G	ORBITAL
	RESTRAINT/ PROTECTIVE DEVICE REMOVE	M A G	M A G	A M G	M A G	M A G			M A G	ORBITAL
	EXP STOWAGE REMOVAL				M A/G				M A G	ORBITAL
	EQUIP/PANEL POST LAUNCH RECONFIG	M A G	M A G		M A G	M A G			M A G	ORBITAL
HEALTH & C & W VERIFICATION	CONFIG FOR INIT POWER UP	M A G	M A G	M A G	M A G	M A G			M A G	ORBITAL
	POWER ACTIVATING ENABLE	M A/G	M A/G		M A/G	M A G			M A/G	ORBITAL
	CAUTION WARNING VERIFICATION	M A G	M A G		M A G	M A G			M A G	ORBITAL
	FUNCTIONAL HEALTH CHECK	M A G	M A G	A M G	M A G	M A G			M A G	ORBITAL
BRIEF	PREPASS BRIEFING	A M/G	A G/M	A M/G	A M/G	A			A M/G	ORBITAL PARTICIPATION REQUIRED
PRE PASS ACTIVITIES	PREPASS EQUIP CONFIG	M A G	M A G		M A G	M A G			M A G	ORBITAL
	EQUIPMENT POWER UP	M A G	M A G	M A G	M A G	M A G			M A G	ORBITAL
	CAUTION & WARNING CHECK	M A G	M A G		M A G				M A G	ORBITAL
	FUNCTIONAL HEALTH CHECK	M A G	M A G	A M G	M A G	M A G			M A G	ORBITAL
	COMMAND LOAD VERIFICATION	M A G	M A G	M A G	M A G	A G M				MIXED PREFERENCE
	EQUIPMENT CALIBRATION				M A G	A M G				MIXED PREFERENCE
EXPERIMENT OPERATIONS	MONITOR (EQUIP/D&C C&W)	M A G	M A G	M A G	M A/G	M A G			M A G	ORBITAL
	MODE CHANGE	M A G	M A G		M A G				M A G	ORBITAL
	R/T DATA ANAL				M A G				M A G	ORBITAL

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TABLE 3-10

ORBITAL MANNED ACTIVITY SUMMARY (CONT'D)

		FAR UV	SLED	SEXTANT	FRAT	OCMD			SUMMARY	REMARKS
EXPERIMENT OPERATIONS (cont'd)	EQUIPMENT OPTIMIZATION	////	////	////	////	M A G			M A G	ORBITAL
	POINTING OPTIMIZATION	A/G M	A/G M	////	////	////			A/G M	AUTOMATED/GROUND
	TARGET SELECTION	M A G	////	A/G	////	////				MIXED PREFERENCE
	DATA MANAGEMENT	////	A G/ M	////	M A G	////				MIXED PREFERENCE
	COMMAND INITIATION	M G/A	M/A G	M/A G	M A G	A M/G				MIXED PREFERENCE
	EXP OPS VERIFICATION	M A G	M A G	M/A G	M A G	A M G				MIXED PREFERENCE
	GROUND CO-ORD	M A/G	A G/A	A G M	////	A M G				MIXED PREFERENCE
	MANUAL PHOTOGRAPHY	////	////	////	M A/G	////			M A/G	ORBITAL
	EVENT ENABLE	////	M A G	////	M A G	M A G			M A G	ORBITAL
	SEQ/CONFIG VERIFICATION	M A G	M A G	M A G	M A G	M A G			M A G	ORBITAL
	OPERATIONAL COMMENTARY	M A G	////	////	M A/G	////			M A/G	ORBITAL
	COMMAND EXECUTION	M A G	M A G	M G A	M A G	M A G			M A G	ORBITAL
	RMS ACTIVITIES	////	M A/G	////	M A G	M A/G			M A/G	ORBITAL
	ELEVATION/ RETRACTION OPS	////	M A/G	////	M A G	////			M A G	ORBITAL
	DEPLOY/JETT OPS	////	M A G	////	M A G	////			M A G	ORBITAL
POST OPERATIONS CONFIGURATION	EQUIP POWER DOWN	M A G	M A G	M A G	M A G	M A G			M A G	ORBITAL
	EQUIP SAFING/ RECONFIG	M A G	M A G	////	M A G	M A G			M A G	ORBITAL
	DATA ANNOTATION/ STORAGE	////	////	////	M A G	////			M A G	ORBITAL

TALBE 3-10

ORBITAL MANNED ACTIVITY SUMMARY (CONT'D)

		EAR UV	SLED	SEXTANT	PRAT	OCMD				SUMMARY	REMARKS
BRIEF	POST PASS DEBRIEF	A M/G	A M/G	///	A M/G	A M/G				A M/G	ORBITAL PARTICIPATION REQUIRED
PRE LANDING PREPARATIONS	EQUIPMENT STORAGE	///	///	///	M A G	///				M A G	ORBITAL
	COMPLETE POWER DOWN/ SAFING	M A G	M A G	///	M A G	M A G				M A G	ORBITAL
	RESTRAINT/ PROTECTIVE DEVICE INSTAL	M A G	M A G	A M G	M A G	M A G				M A G	ORBITAL
	DATA STORAGE	///	///	///	M A G	///				M A G	ORBITAL
	C&W CHECK	M A G	M A G	///	M A G	M A G				M A G	ORBITAL
EVA	PLANNED EVA	///	///	///	M A G	///				M A G	ORBITAL
	SPECIAL CONTINCENCY	///	///	///	M A G	///				M A G	ORBITAL

3.7 MANNED ACTIVITY TIMELINE

In addition to defining manned interface activities, a mission timeline was developed to determine the nature and sequence of operational activities required for a nominal mission.

A hypothetical mix of the SLED and OCMD payloads was used as a basis for generating the timeline. The SLED payload was assumed to have minimum operational restrictions regarding orbital location, inclination and altitude. The OCMD payload, however, required a ground track repeat cycle to optimize ground station contacts at MIT and Holloman AFB and an orbital inclination sufficient to provide contact opportunities with both of these ground sites.

The orbital parameters selected to satisfy the OCMD requirements were a circular orbit having an inclination of 57° and an altitude of 296.8 NM. These parameters provided a 15 orbit ground track repeat cycle for each day of operation. Figure 3-1 shows the daily ground track of this orbit over the continental United States. Also illustrated in Figure 3-1 is an assumed nominal contact range of 900 NM for the OCMD payload referenced to the MIT and Holloman AFB ground stations.

For a nominal 7-day mission, the number of contact opportunities with the OCMD ground stations was calculated and are provided in Table 3-11. A total of 48 contact opportunities exist for the operational OCMD mission providing a total potential of 336 minutes of contact time. Since the OCMD operational times are fixed to a definite set of orbital positions, they become the drivers for the hypothetical STP mission. Therefore, the SLED payload activities were scheduled to minimize conflicting operations with the OCMD payload.

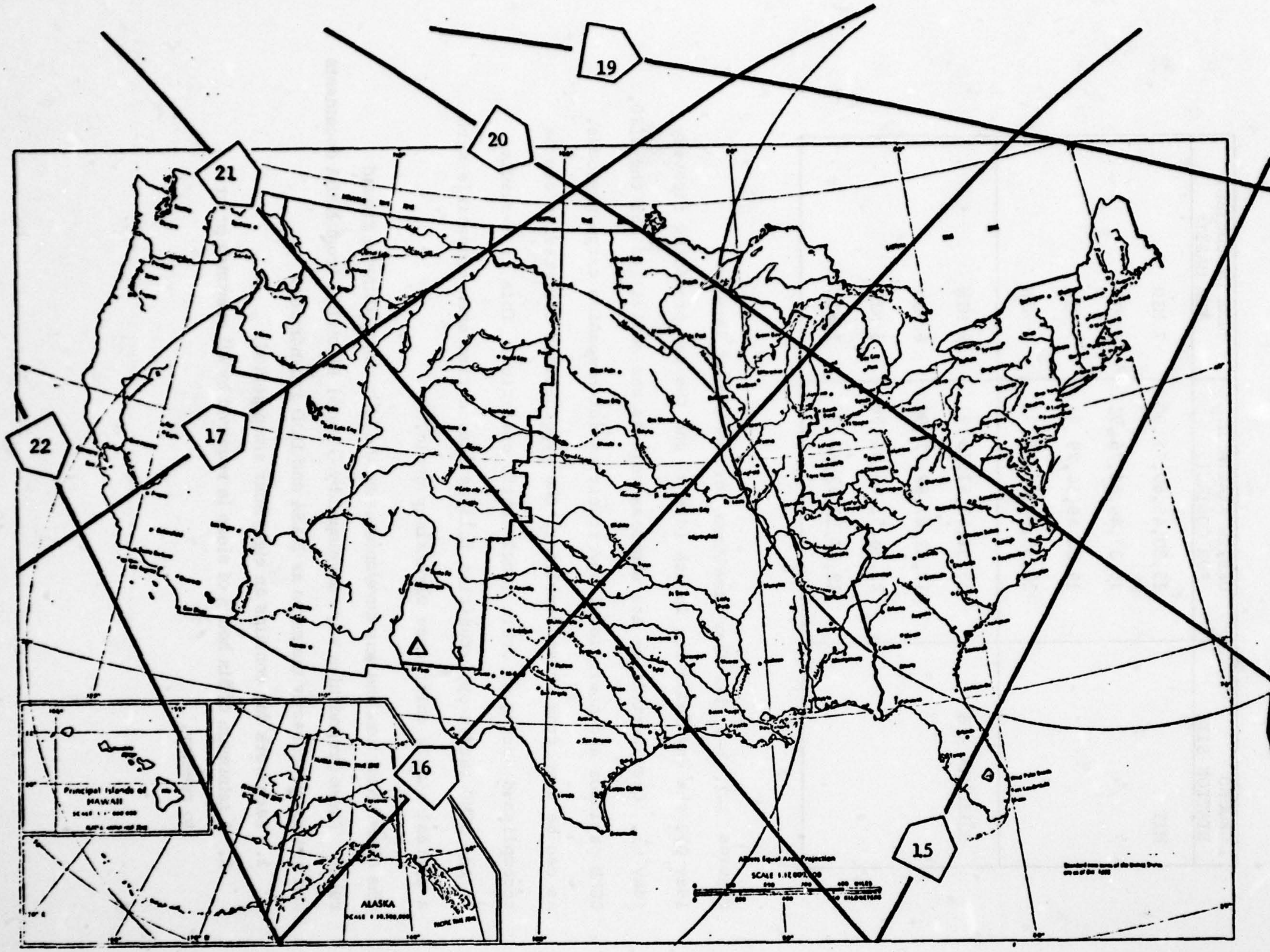


Figure 3-1 Typical ground track repeat cycle for second orbital day

Table 3-11 OCMD Contact Opportunities

GROUND STATION SITE	ORBITS AVAILABLE FOR CONTACT	TIME OF CONTACT PER ORBIT
MIT	15,30,45,60,75,90	7 MIN
	16,31,46,61,76,91	6 MIN
	19,34,49,64,79,94	7 MIN
	20,35,50,65,80,95	7 MIN
HOLLOMAN AFB	16,31,46,61,76,91	8 MIN
	17,32,47,62,77,92	6 MIN
	21,36,51,66,81,96	8 MIN
	22,37,52,67,82,97	7 MIN

Figures 3-2, 3-3, 3-4 show timelines for the day of launch (day 0), the day following launch (day 1) and the day preceding recovery (day 6). Crew activities are shown as well as the activities for the SIED, OCMD payloads and operational opportunities for companion cargo payloads. As can be seen from these timelines, the hypothetical STP mission can be accomplished during on orbit single shift operation. This is a result of the OCMD target opportunities falling into a time span compatible with a nominal single shift crew work/sleep cycle.

The operational timeline was developed using the following additional ground rules. These groundrules were developed by General Electrical from NASA documents and are not necessarily the same as NASA and DOD groundrules.

1. Each work day contains an eight hour sleep period.
2. A minimum of six hours of sleep is required by all crewmen prior to reentry.

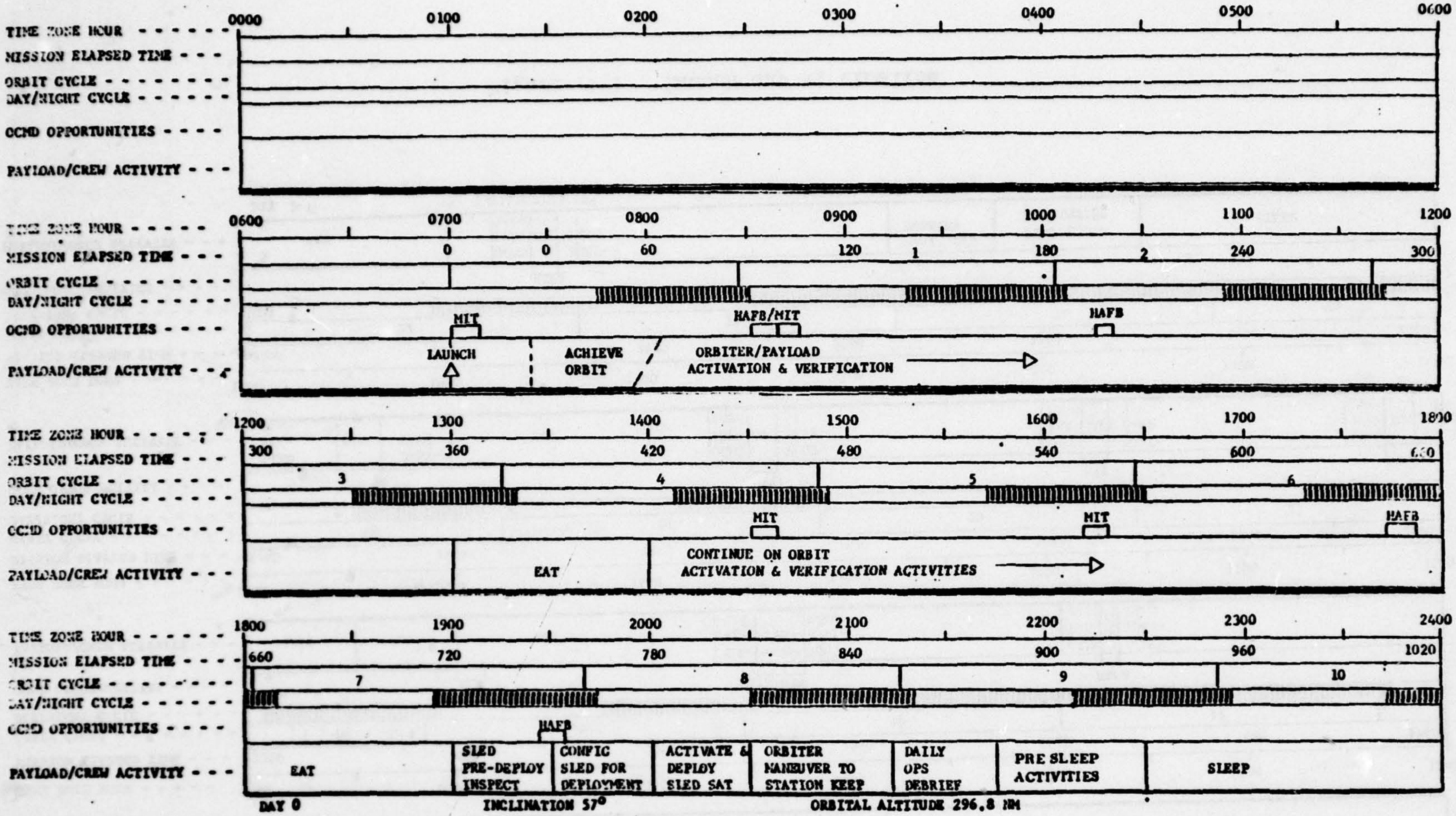


Figure 3-2 Launch day operational timeline

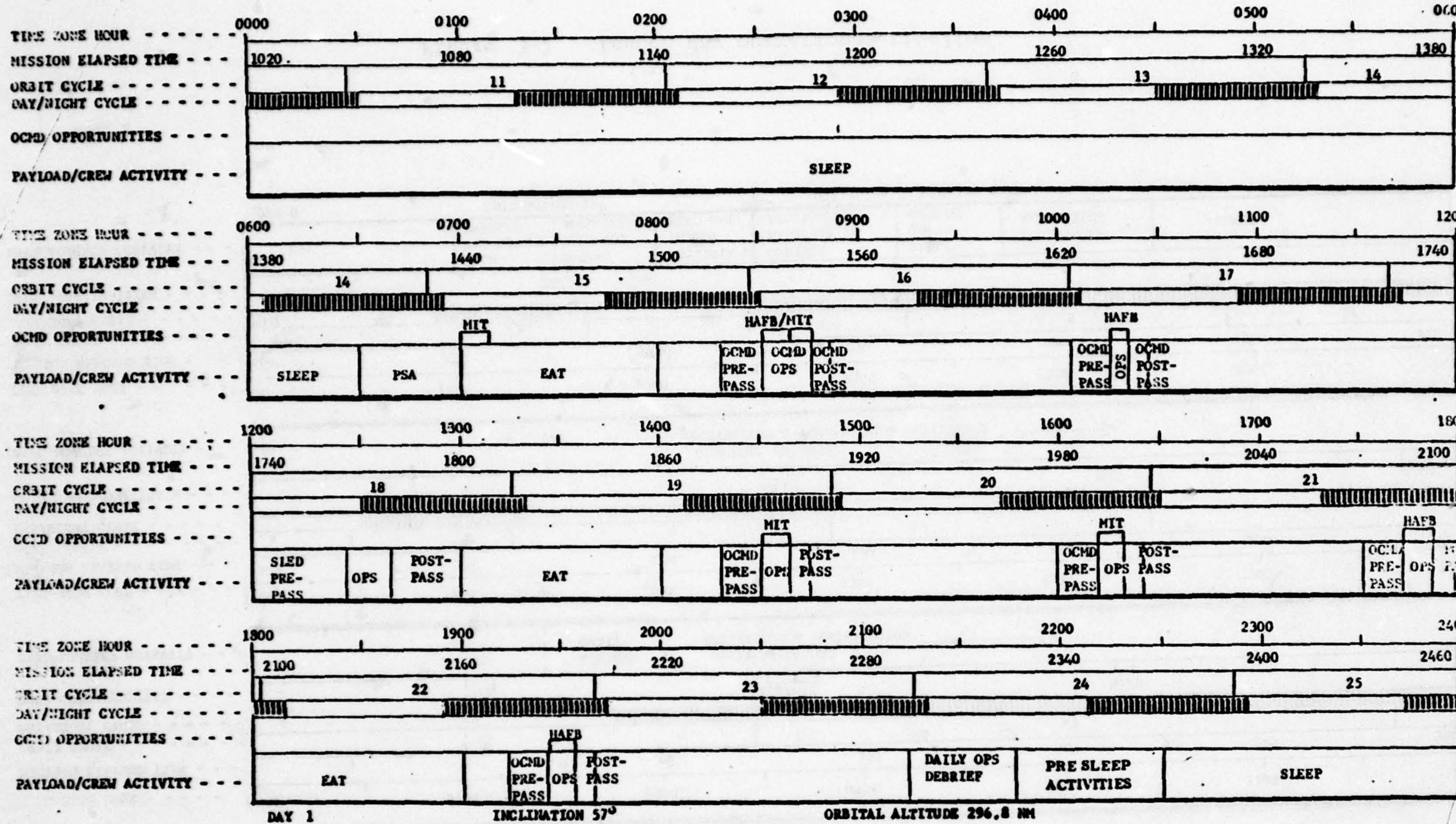


Figure 3-3 Launch day +1 timeline

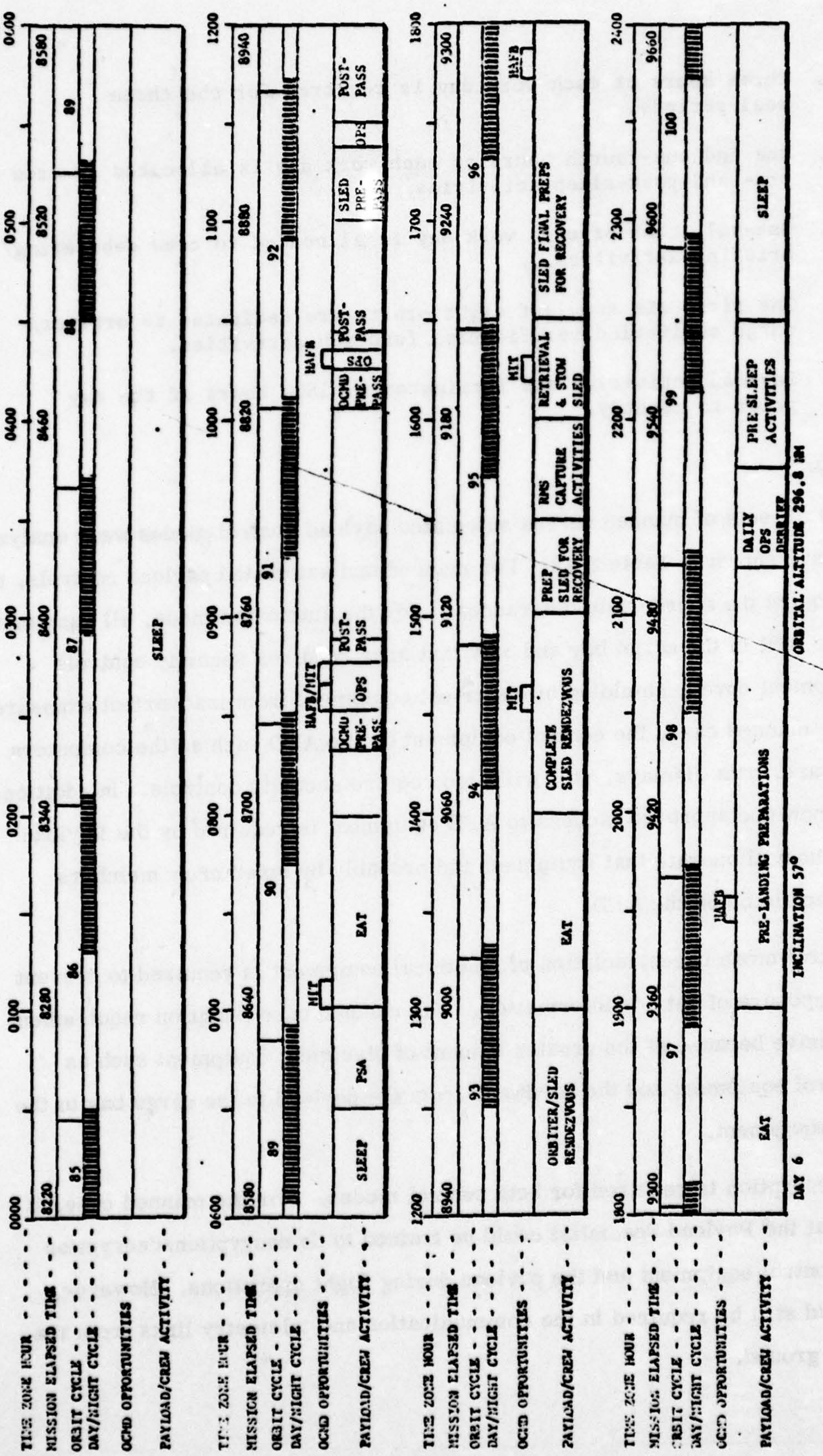


Figure 3-4 Recovery day -1 timeline

3. Three hours of each work day is required for the three meal periods.

4. One and one-fourth hours of each work day is allocated to crew pre- and post-sleep activities.

5. One-half hour of each work day is allocated to crew debriefing/ briefing activities.

6. The first six and last eight orbits are dedicated to orbiter/ cargo activation/verification function activities.

7. Payload activities are terminated by 1800 hours of the day prior to reentry.

3.8 Security

The security aspects of manned versus automated payload control modes were analyzed. The results are shown in Table 3-12. For manned and automated payload controls, the crew will require the appropriate clearances. For the automated mode, all equipment will be on the STR in the cargo bay and only that area requires security controls such as equipment cover, shielding of electrical equipment from inadvertent exposure, etc. For the manned case, the control equipment on the AFD such as the computers with its software, data displays, etc. will also require security controls. In addition, the need to know and approved access to AFD equipment is required by the Payload Specialists who will operate that equipment and probably by other crew members who have a need to be on the AFD

For both control mode cases, isolation of electrical equipment is required to prevent inadvertent exposure of data or information. The manned case isolation requirement is more extensive because of the greater amount of electrical equipment such as the AFD control equipment and the hardware from the payload in the cargo bay to the AFD control equipment.

Encryption/decryption is required for both control modes. For the manned case, it is possible that the Payload Specialist could be trained to do encryption/decryption between the control equipment and the payload during flight operations. However, hardware would still be required in the communication and telemetry links from the Orbiter to the ground.

The maintenance of security is more difficult with man in the loop because of the possibility of human error. A totally automated system minimizes the number of people involved and on the Orbiter is the most secure control mode.

The security aspects will have an impact on the selection of a dedicated control system as compared to potential use of the IUS on Teleoperator control systems as discussed in Sections 4.4 and 4.5. The security requirements during ground operations are almost the same for automated and manned control modes. The slight difference is due to the additional equipment utilized in the manned control mode, i.e., AFD hardware. Both modes require controlled areas with alarms, guards and limited access; covers for equipment; clearances for all personnel and need to know lists for people who will work with the equipment and data.

The conclusion drawn from the security analysis is that there is little difference in the complexity and cost of providing a secure system for the automated and manned control modes. The automated control system shows a slight advantage over the manned control mode but it is not an overriding factor in control mode selection. For all activities in controlling the payloads during flight operations shown in Tables 3-5 through 3-9, the following rating applies to the security aspects:

o Automated Control	+
o Manned Control (by Orbiter crew)	0
o Ground Control (by ground crew)	-

	MANNED	AUTOMATED
PERSONNEL CLEARANCE & EQUIPMENT HANDLING	REQUIRED (2 LOCATIONS)	REQUIRED (1 LOCATION)
NEED TO KNOW ACCESS	REQUIRED (FOR FLIGHT)	NOT REQUIRED (FOR FLIGHT)
ELECTRICAL ISOLATION	CAN BE HARDWIRED TO ARD., BUT STILL REQUIRED	REQUIRED
ENCRYPTION/DECRYPTION	• MAN + TRAINING CAN PROVIDE DURING OPERATIONS • HARDWARE REQUIRED FOR GROUND COMM. & DATA HANDLING	REQUIRED
RELIABILITY	MAN IN LOOP SOMEWHAT LOWERS RELIABILITY	HIGH

AFFECTS CHOICE OF EQUIPMENT

- IUS
- TELEOPERATION
- DEDICATED

Table 3-12 Security Aspects of Manned vs. Automated Operations

SECTION 4

PAYLOAD CONTROL EQUIPMENT

4.1 INTRODUCTION

The payload control equipment (PCE) consists of the equipment required by the payload or mission specialist to control and operate DOD payloads mounted on an Standard Test Rack in the Orbiter Cargo Bay. This section identities the equipment requirements, identifies equipment sources from current programs, evaluates existing and new equipment, and finally recommends an approach and provides a list of required equipment.

The sources of potentially usable payload control equipment are console and rack mounted equipment designed, and in some cases built, for use on the following programs.

- Basic Orbiter controls on the AFT Flight Deck in conjunction with the Orbiter General Purpose Computer
- Spacelab AFT Flight Deck controls used in conjunction with Iglooas part of a pallet only configuration
- Interim Upper Stage (IUS) Communication Interface Unit used to operate the IUS thru post-deployment activity
- Spinning Solid Upper Stage (SSUS) Controls
- Teleoperator Retrieval System (TRS) controls
- Materials Processing in Space/Spacelab Controls

In addition to the above systems, a new system was defined using off the shelf equipment. This system is aimed at operating a variety of DOD payloads on STR.

Each of the control systems will be evaluated against the general requirements defined in Section 4.2. A control approach is recommended and an equipment list defined.

4.2 PAYLOAD CONTROLS REQUIREMENTS

Payloads controls on the AFT Flight Deck (AFD) is an important issue which has been addressed. The accommodations constraints imposed by the orbiter which influenced the results of this study are as follows:

(1) Available panel area, (2) available equipment volume, (3) weight constraints, (4) thermal dissipation, (5) power, and (6) video interface.

The next paragraph defines those requirements which are imposed for those experiments which will be assembled into a mission payload on the Standard Test Rack. Requirements which are specifically discussed include display requirements, control requirements, computer hardware requirements, computer software requirements and a brief evaluation on the operational impact of not using USAF standard SGLS equipment for communications.

4.2.1 CONTROL AND DISPLAY REQUIREMENTS

Requirements for a Control and Display System have been derived from several sources and can be classified accordingly. Functional requirements have been obtained from analysis of typical operational scenarios for the various instruments to be flown on STR. Physical requirements are the result of orbiter AFD accomodations constraints and the functional requirements. In addition, the multi mission/ multi-use aspect of STR places certain requirements on the C & D system.

4.2.1.1 FUNCTIONAL REQUIREMENTS FOR CONTROL & DISPLAY

The C & D system must provide the functions to the payload specialist station to enable experiment operations, experiment pointing control, a minimal amount of experiment performance evaluation, and experiment computer software updating.

Experiment operations requirements identify those capabilities which the payload specialist uses to communicate with the payload and vice versa. Necessary switches, buttons, and keyboards, must be provided so that payload subsystems can be activated and deactiviated and both discrete and parametric commands can be delivered to the payload to direct payload operations. Displays must be provided so that the payload specialist can verify implementation of commands which have been entered, monitor execution of the experiment timeline, and to monitor engineering or science data to assure proper and safe operation of the experiment.

The capability to monitor and control individual experiment pointing must be provided.

Capability should be provided for payload specialist updating of experiment computer software because of the effective slow uplink command bit rate (+100 BPS) due to holds for error checks, command repeats and potential competition for command uplink from Orbiter and other users. This updating capability can be limited to modifying constants, table entries, etc. and need not include an aynamic reprogramming capability.

While the STR itself requires some control and monitoring it has been determined that the functional requirements identified for experiment control will be sufficient for the STR.

4.2.1.2 PHYSICAL REQUIREMENTS FOR CONTROL & DISPLAY (C & D)

The equipments selected for the control & display system must operate within the physical constraints imposed by the AFD accomodations (see para 4.3), provide the functions listed in the previous paragraph and be flexible enough to support several experiments on a single flight, and be capable of being used on a flight to flight basis without being modified. A final requirement is that the STR C & D system must not require a disproportionate share of available AFD accomodations such that other payloads would be excluded from flying with STR. The cost impact of such an exclusion would be dramatic. The physical elements of principal concern are panel surface area, equipment volume, and power. The requirements for each of these is summarized in Table 4-1.

TABLE 4-1 C & D PHYSICAL RESOURCE REQUIREMENTS

RESOURCE	AMT. AVAILABLE **	STR REQ'MT. *
Panel Surface	23.33 sq. ft.	4.21 sq. ft.
Volume	21.65 cu. ft.	5.43 cu. ft.
Power	750 watts	50 watts - standby 600 watts-operating

*System design requirement based on limiting equipment to one panel in AFT Flight Deck.

** IUS requirements: Panel volume 5.43 cu. ft.
Panel surface area 4.21 sq. ft.
Power 150 w(CIU) up to 5 hours

The panel surface area for the C & D system must fit in 4.21 sq. ft. which is 25% of available surface areas.

The volume of C & D electronics must be less than 5.43 cu. ft.

Power consumption must be less than 600 watts when in operating modes and 50 watts in stand-by modes. The stand-by mode consumption figure is somewhat arbitrary while the operating modes figure is what would be available if 3 companion payloads were permitted 50 watts of stand-by power.

4.2.2 COMPUTER REQUIREMENTS

Recent technological innovations in computer hardware have substantially lowered the unit costs of computer equipment and has caused emphasis to be shifted to software development and integration as cost drivers for a data system since both are highly labor intensive activities. This section discusses both hardware and software requirements for the C & D computer system.

Computer hardware requirements are discussed below:

- o The computer itself should be a micro-processor with a 16 bit word-length in order to provide sufficient computational accuracy for engineering unit conversions, etc.
- o The computer must consume little power.
- o It must use a standard, commonly used instruction set (i.e., IBM, PDP-11) in order to facilitate software development, test, and integration on other than flight hardware.
- o The instruction set should contain both fixed point and floating point arithmetic instructions.
- o The computer architecture should be highly modular and reconfigurable from mission to mission so that extra equipment is not flown and cause needless consumption of power and space resources.
- o A recorder and storage device is required to store experiment data and hold computer programs.

- o The computer should be of sufficient reliability so as to preclude necessity of redundancy in order to achieve .99 reliability.
- o Serial and parallel I/O channels are required to accomodate both high rate and low rate data.

The following software requirements have been identified:

- o A common higher order language programming capability is required.
- o Common processing functions should be reuseable from mission to mission by developing an operating system which not only manages system resources but provides the following commonly used services to experiments:
  - limits checking and alarm reporting
  - process keyboard inputs and service display requests and command entries.
  - formatting down link data.
  - special self interpretive flight instruction set.

4.3 AFT FLIGHT DECK DESCRIPTION

The AFT Flight Deck is the area in which man will function to control and operate the DOD sortie payloads. An isometric of the AFT flight deck area is shown in Figure 4-1. It is designed to accommodate two functioning crewmen in a clear floor space of 6½feet by 3½feet. One of the crewmen is the Mission Specialist who is controls the Orbiter/payload interfaces. The other is the Payload Specialist who controls and operates payloads. When it is necessary to maneuver the orbiter from the AFT Flight Deck, the pilot or commander will operate the AFT Flight Deck Orbiter flight controls. The Mission Specialist and the Payload Specialist functions are secondary and the specialists will stand out of the way.

The panel layout on the AFT Flight Deck is shown in Figure 4-2. The view is looking AFT along the Orbiter X axis. The shaded panels are available for payloads. The unshaded panels are dedicated to the orbiter. Panel R-12 contains the Orbiter

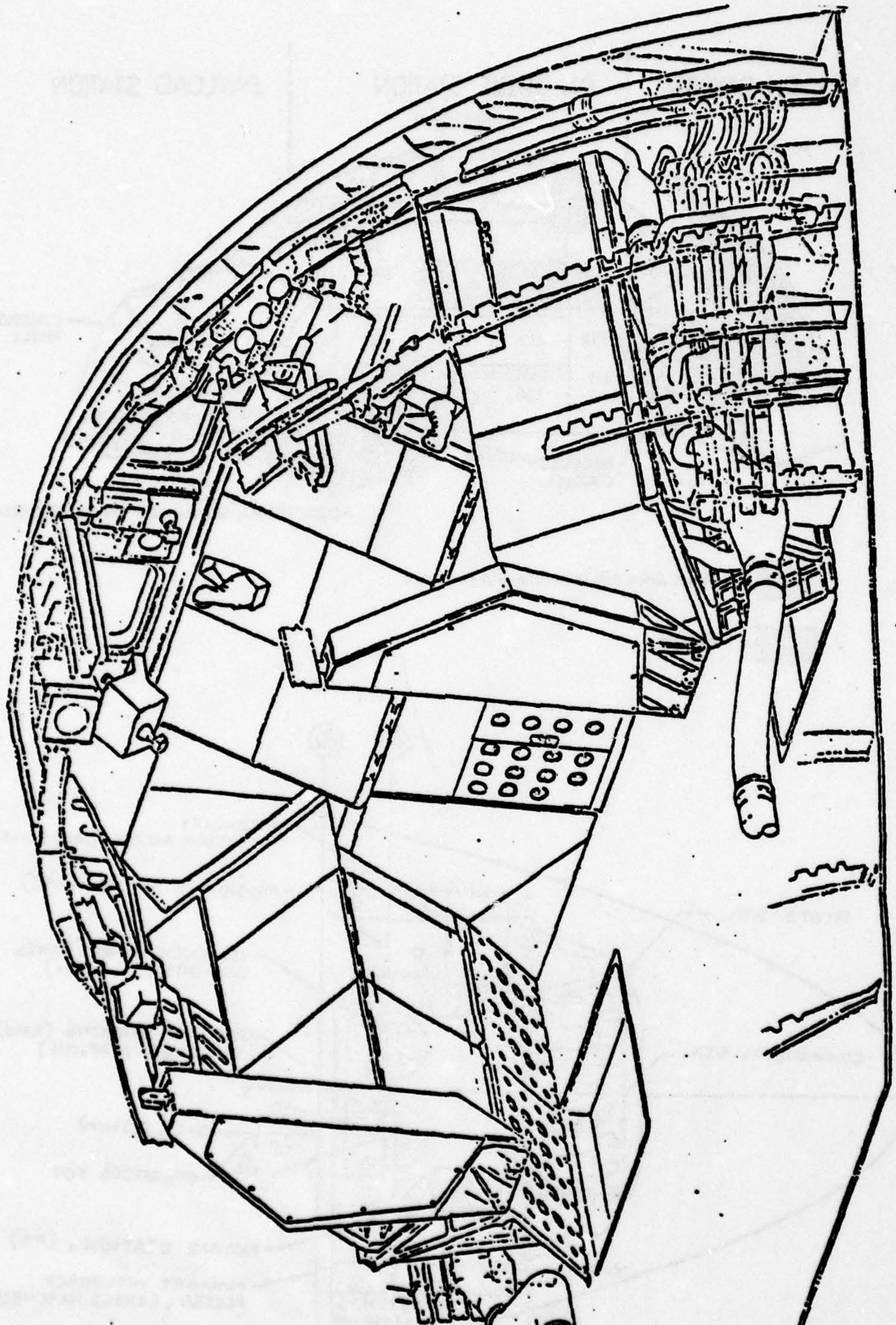
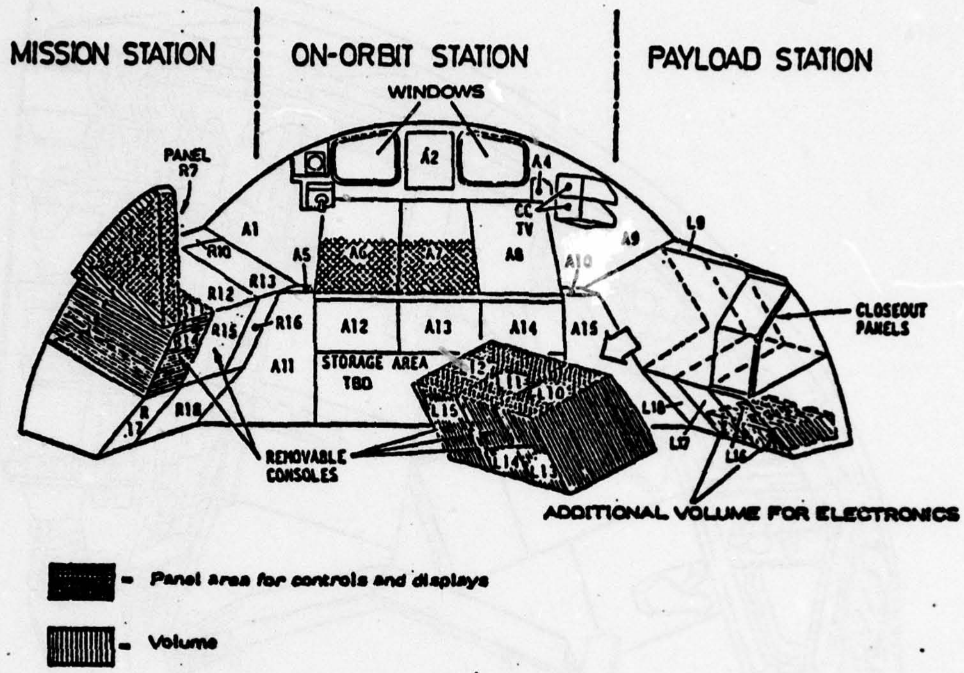


Figure 4-1 Aft Flight Deck



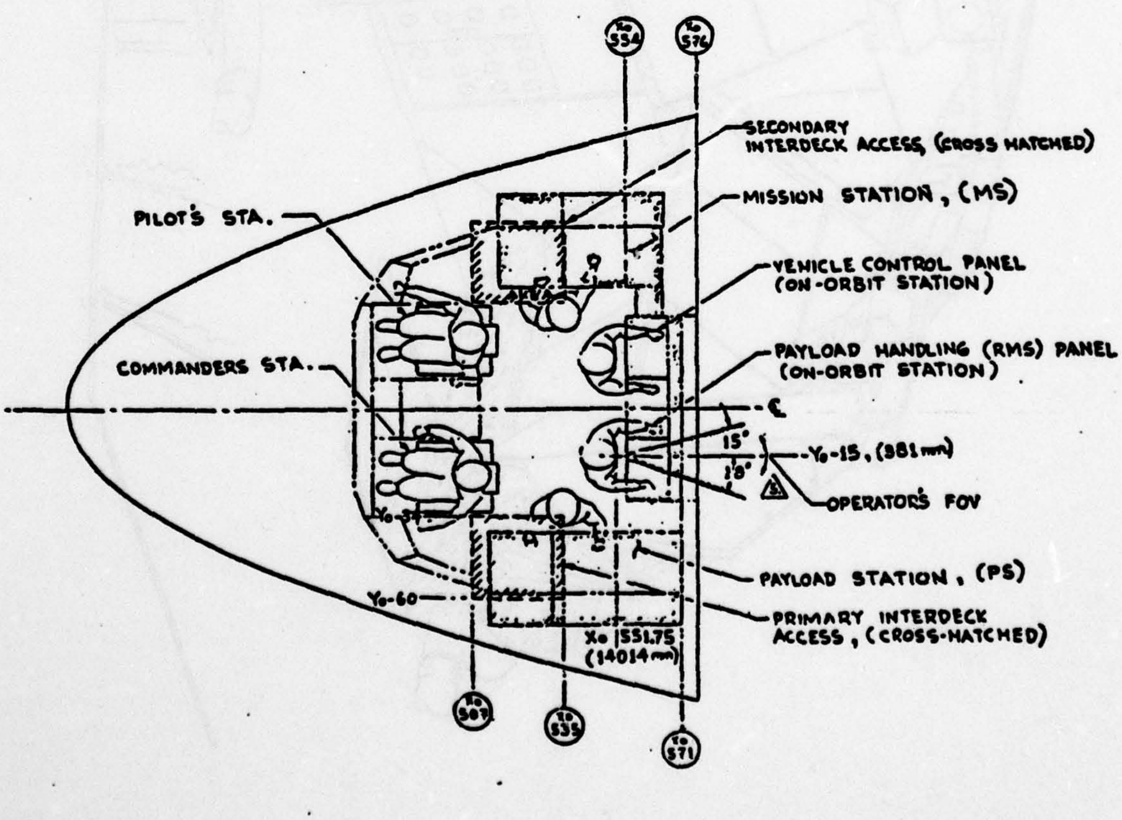


Figure 4-2 Aft Flight Deck Panel Arrangement

control keyboard and CRT which can be utilized by payloads when not being used by the Orbiter. Other payload utilizable areas are as follows:

- o A standard switch panel usually mounted an L-12 panel surface
- o Closed circuit TV
- o Windows
- o Audio communication system (panel L-9 in the Payload specialist station.

In addition, the Remote Manipulator System provides payload services (operated by the Mission Specialist) and is controlled from Panel A7, A8 and Panel 140 (hand controller adjacent to panel A8, not shown).

A summary of the surface area and volume avalable for payloads control equipment is given below.

Table 4- 2 SURFACE AREA AND VOLUME FOR PAYLOADS CONTROLS

	SURFACE AREA, FT^2	VOLUME, FT^3
A6-A2	1.84	1.07
A7-A2	1.84	1.07
L10	2.83	4.31
L11	2.83	4.31
L12	2.83	4.31
L13	1.83	-
L14	1.83	-
L15	-	-
R7	1.84	0.97
R11	2.83	4.31
R14	1.83	-
ADDITIONAL	-	1.3 (Under L10 and L11)
TOTAL	22.33	21.65

Panels R11, L10, L11, L12, are standard 19 inch racks conforming to MIL-STD-189 and can accommodate 135 pounds of equipment. Panels R-7, A6A2 and A7A2 can carry 30 to 40 pounds of equipment.

The electric power available for payloads on the AFT Fight Deck is given in the table below.

TABLE 4-4 POWER AVAILABLE FOR PAYLOADS - AFT FLIGHT DECK

	POWER, WATTS *		
	PAYLOAD OPERATIONS	ORBITER OPERATIONS	GROUND
AVERAGE	750	350	750
PEAK	1000**	420***	1000*

* Not Part of Payload Bay Power

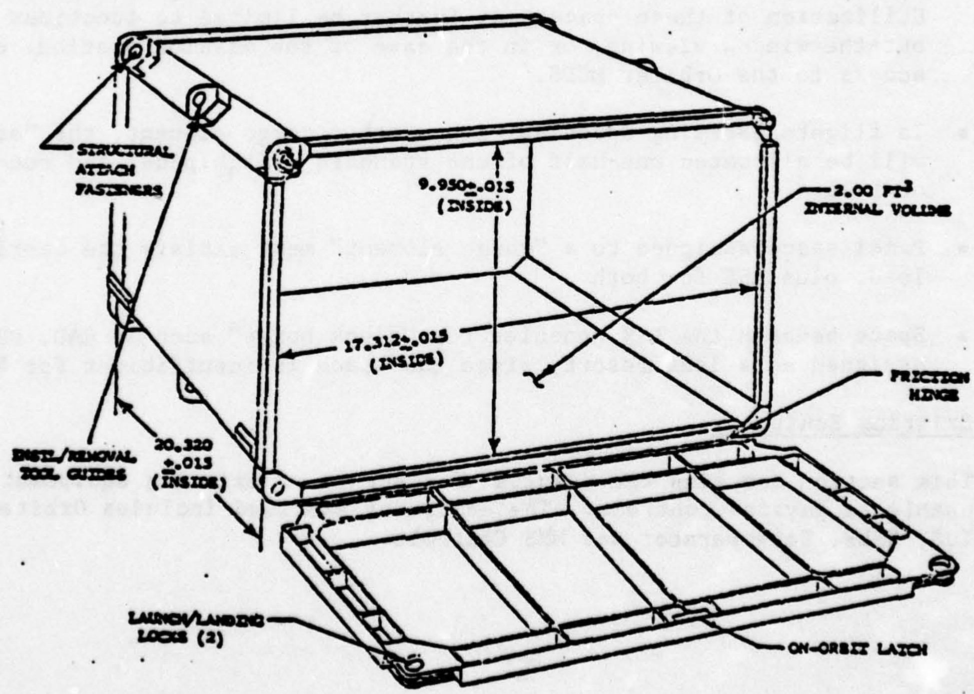
** 15 Minutes/3 hours

*** 2 Minutes/Mission phase

AC electrical power is provided at various interfaces at 115 $\pm$ 5 volts.

The electrical energy used on the AFT Flight Deck is chargeable to the individual user payloads, for determination of costs impact over the 50 KWH allowable for payloads. (See Reference 2). Cooling of AFT Flight Deck payload control equipment is provided by drawing air from the cabin through the equipment into the Orbiter ducting system. Cooling is distributed between the Payload and Mission Stations, as required, so long as the maximum total heat load is not exceeded. The Orbiter provides cooling for the removal of a maximum of 750 watts average, and 1000 watts peak (15 minutes once every 3 hours), from mission and payload stations during on-orbit operations. Cooling in excess of 350 watts requires equal reduction in the cooling provided by the payload heat exchanger. For prelaunch, ascent, descent, and post landing the combined maximum of 350 watts are Orbiter-provided. The above values shall include up to 100 watts cooling for AFD payload equipment consuming small quantities of power (10 watts each) by direct radiation or convection to the cabin; specific forced-air cooling is not provided. Storage of additional loose payload equipment is generally not available on the AFT Flight Deck. (See Reference 6). Lockers A-16 and A-17 storage area (See Figure 4-2) contain mobile TV and communications equipment. It is possible that some or all of this locker volume is not used on IUS flights. It would then be available for payload equipment. There are 89 cubic feet of storage volume on the mid-deck some of it in a limited number of standard storage containers. The rest is below the mid-deck platform. The standard container can hold 60 pounds of equipment.

FIGURE 4- 3 STANDARD MID-DECK STORAGE CONTAINER



The JSC proposed ground rules for usage of the panel facilities are shown below;

Table 4-3 Proposed AFD Panel Space Guidelines for Mixed Cargo Elements

- Space will be allocated on the basis of equal shares for four cargo elements. Larger elements (e.g., IUS) may be allocated two shares.
- Location L-12 will normally be utilized for the GFE standard switch panels (1 or 2, as required) and the GE manual pointing control/jettison panel.
- One standard switch panel is required as a minimum for all flights, to provide power distribution for the timing buffer and other AFD users.
- One-half of one GFE standard switch panel (12 switches and 12 talkbacks) is allocated to each of up to four cargo elements.
- One-half of the space of L-10 or L-11 (19"Wx10 ½"Hx20"D) is available for user-furnished items for each of four cargo elements.
- Specific location of panels on the AFD is at the option of the STS operator and may vary from flight to flight.
- Additional panel space at the orbit station and the mission station is available, but limitations of wiring access, cooling, and panel depth are severe. Utilization of these spaces may further be limited to functions which require out-the-window viewing, or in the case of the mission station, concurrent access to the Orbiter MCDS.
- In flights carrying Spacelab with another cargo element, the "other" element will be allocated one-half of one standard switch panel and one-half of L-10 or L-11.
- Panel space assigned to a "cargo element" must satisfy the carrier and its payload, plus ASE for both.
- Space beneath the PSS consoles for "black boxes" such as RAU, DEU, should be assigned as a last resort, since the space is insufficient for 4-way sharing.

4.4 Existing Equipment

This section contains the results of a survey of existing equipment potentially usable as payload controls. The equipment examined includes Orbiter, Spacelab, IUS, SSUS, Teleoperator and MMS Controls.

4.4.1 ORBITER CONTROLS

4.4.1.1 ORBITER CONTROLS/STR INTERFACE

The STR system defined in Reference 1 shown in Figure 4-4 must be compatible with the orbiter controls defined in Paragraph 4.4.1.1. The STR system was designed to allow DOD payload control from the ground thru the SGLS communication system. An analysis of the Orbiter controls system shows that it has sufficient capability and capacity to operate and control DOD experiments and the STR, including an STR mounted pointing system. (See table 4-5)

TABLE 4-5 ORBITER GPC CAPABILITY

- Accomodating of a large number of switching functions
- Processing of 500 discrete/analog parameters for
  - data acquisition
  - failure detection and annunciation
  - table maintenance
  - checkpoint
  - display
  - downlist
- use up to 5 displays
  - 4 MDM discrete command (20 items/display)
  - 1 SM-type or table maintenance or subsystem configuration monitoring.

However, there are some limitations and some additional STR hardware and interface hardware which are required. These will be discussed in the following paragraphs which also describe the usage of the Orbiter controls system. Programs for controlling, operating and monitoring the DOD payload/STR may be stored in the GPC. This requires that a definition of the software and GPC requirements be available 36 months prior to flight since Orbiter capabilities are shared, many of them on a ¼,½, 3/4 or total share basis. Software may be compatible with the GPC format and therefore will probably be developed by JSC/IBM. This involves a DOD/payload contractor/STR integrator/RI/JSC/IBM interface. The programs can be accessed from the AFT Flight Deck via the keyboard. Discrete commands to the payload/STR are transmitted from GPC via MDM to the payloads. Serial digital commands flow from GPC to MDM thru the Payload Signal Processor and then to the sortie payload at 8 KBPS. (See Reference 2). Data from the payload for display is routed from the payload to the PDI to the PCMMU to the GPC then to the CRT. This data is limited to engineering data at 64KBPS. If high or medium range payload data is to be displayed, it must be subcommutated to 64KBPS, engineering data level. This would degrade the resolution and may

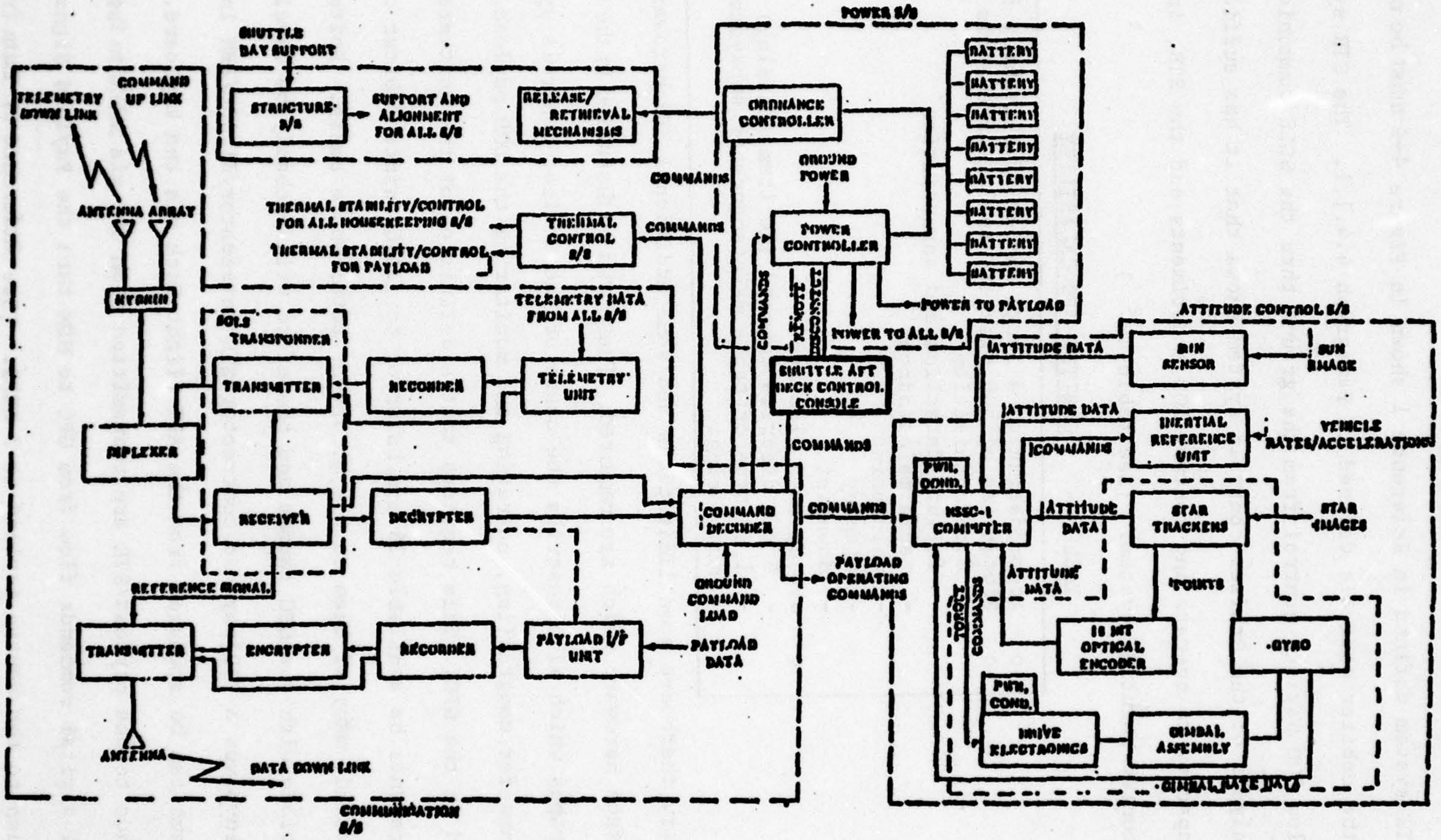
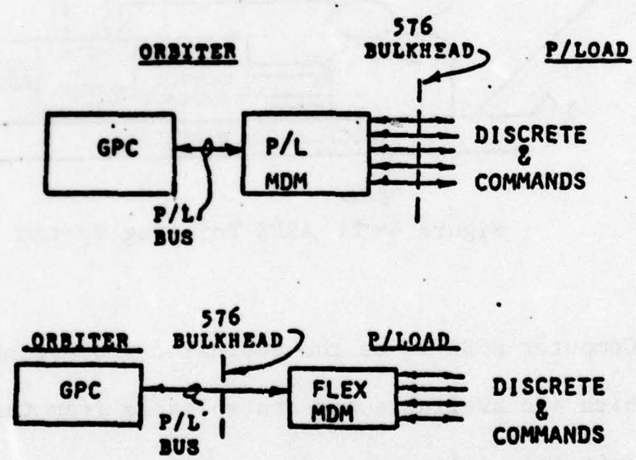


Figure 4-4 STR System Block Diagram

rendor the data display unusable.

To make the STR system compatible with the Orbiter Controls system, an encoder must be added so that commands will be compatible with the existing decoder and permit control from the ground as an alternate commanding mode. In corporated in the System encoder would be a capability for switching from on-board to ground control commanding modes. In addition, a buffer must be added to the telemetry unit for low rate data and to the payload interface unit for high rate data. These buffers would control data paths to either ground or AFD or both. In addition to these changes, adding an FMDM (Sperry Modular Interface Unit Type) at the STR(Figure 4-5) would reduce the number of wires to the AFD control panels. This would reduce payload flight weight and ease the integration and orbiter capability sharing problems.

FIGURE 4-5 FMDM LOCATION ADVANTAGE



This FMDM is similar in function to the MDM described in paragraph 4.1.1.1 with half of its capacity

Controlling a pointing system can be accomplished using the Orbiter controls keyboard and data display and the portable MPC. The IPS, ASPS and points pointing systems were considered. Each of these processes stability and pointing in puts and generates commands to its torguers using its own mini-processor or computer. The ASPS system is shown in Figure ~~4-11~~ 4-6 as an illustration. Showing

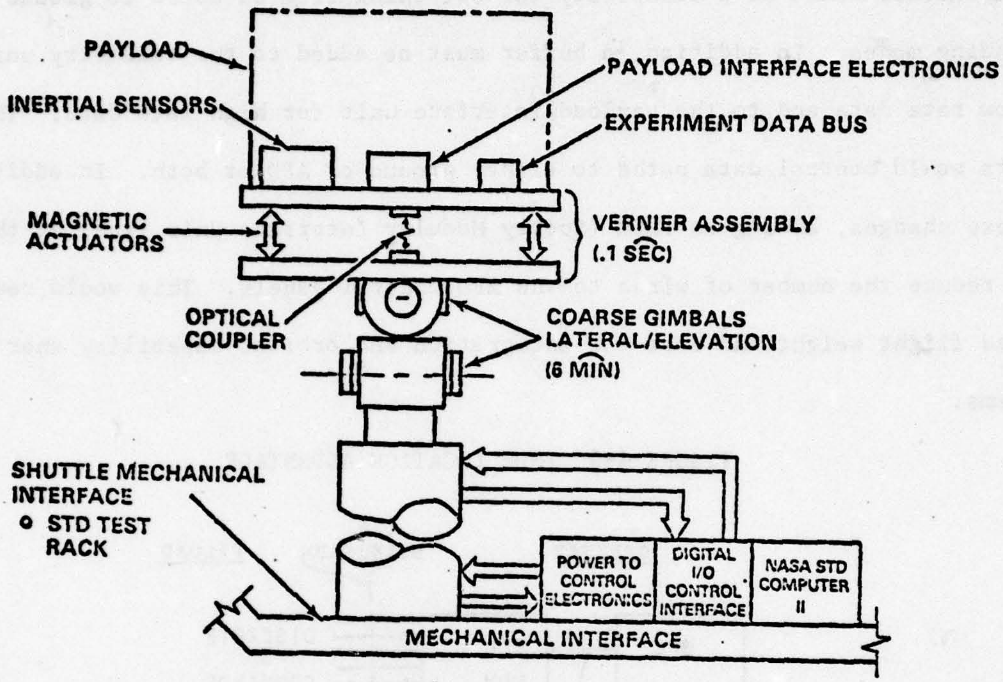


Figure ~~4-11~~ 4-6 ASPS Pointing System

the NASA Standard Computer NSSC-II as the dedicated processing unit. The other Orbiter services which are available and controllable from the AFD are

- Closed circuit television monitors
- Timing inputs
- GH&C inputs

These inputs, if utilized by the payload, can be controlled from existing AFD Orbiter controls and only require the tie to the payload, which is a usage, not a control function.

4.4.1.2 <u>Evaluation of Orbiter Controls Usage For DOD Payloads</u>

The advantages and disadvantages of using the Orbiter controls and the on-board systems to control DOD payloads are as follows:

<u>Advantages</u>

- The system has the capability to control the DOD payloads with certain restrictions (See disadvantages).
- The new hardware required (i.e. FM DM, encoder, harnesses) is minimal. (Since the usage time of these controls by the Mission Specialist to manage and monitor the Orbiter systems is not defined, it may be necessary to provide an additional console, both of which can be used for Orbiter Systems Management or payload control.
- Using Software which is integrated into the Orbiter Muster Measurement list assures that all activities are compatible with the Orbiter activities.

The Disadvantages are:

- Sharing the controls with the Systems Management of the Orbiter and with other payloads limits the availability of the controls for DOD payloads. This situation will vary from mission to mission. On missions where other payloads are deployed, the controls are totally available for the DOD payloads. On Spacelab missions where the Orbiter controls are utilized by Spacelab payloads, the competition for their use exists throughout the mission. The problem of sharing can be alleviated by the use of additional equipment such as panel switches, deploy CRTS, keyboards. However the GPC, MDM and other integral Orbiter equipment could not be duplicated without greatly increased costs.
- There are several limitations on data handling using the Orbiter controls.
  1. The GPC cannot currently be used as part of an automatic control loop. The crewmen can*be alerted via CRT or warning light, but he must initiate the further action.

2. Data processing for interaction is currently not done by GPC. Interactive processing must be done by payload equipment since the GPC is limited to limit comparison functions.

3. Only engineering data can be displayed and monitored. High and medium rate data must be subcommutated in which case, resolution is lost.

- Software must conform to GPC format. This involves a costlier Software effort than for a simpler system such as a micro-processor.

Since RI controls the inputs, JSC manages the software and IBM develops the software, an extensive interface is involved. Integration requires a period of greater than 18 months. The procedure is a follows:

1. Submi and Software requirements to RJ using one or both of the following forms.

   MSR - Measurement Software Requirements

   FSSR - Functional Subsystem Software Requirements

2. RI will prepare inputs on cards and submit them to JSC

3. JSC integrates the requirements with other payload and Orbiter requirements. JSC than directs IBM to prepare the software

4. IBM creates software.

The above procedure must be completed 3 months prior to flight. It must also add time for RI activity and payload integrators to prepare the requirements.

- The software integration and checkout tasks are costlier since integration with other payloads is required, simulators may be necessary etc.
- Security limitations may require the use of a dedicated control system on the AFD.

4.4.1.3 Recommendation

The evaluation of the use of the Orbiter controls for DOD payloads indicates that the capability exists to control those DOD payloads with simple control and monitoring requirements. Because of the sharing, which is on a one fourth basis, with other payloads, the capacity available to the DOD payloads will vary from mission to mission.

Due to these factors, the data handling limitations, and the estimated high software costs associated with GPC, the Orbiter controls are not recommended for complex DOD payloads such as BMD, SLED and HIRISE.

4.4.2 SPACELAB CONTROLS

4.4.2.1 Evaluation

A review of the manned interface capabilities for Spacelab pallet-only type payloads clearly indicates that the Spacelab equipments could be used with the DOD Standard Test Rack (STR) in a manner very similar to the currently planned Spacelab missions on the Space Transportation System.

The Spacelab electronics, controls and displays as presently configured for the Shuttle Orbiter aft flight deck provides a means for the STS Mission Specialist and/or the Payload Specialist to interface and to interact directly with the pallet-only type payloads while they perform their orbital operations in the cargo bay of the Shuttle Orbiter.

If the STR is used for selected DOD experiments aboard the Shuttle in low earth orbit, the Spacelab equipments can be used with the STR to provide a capability for manned assistance to the DOD experiments during their orbital operations.

In order to accomplish this, it will be necessary to integrate the STR with the Spacelab Igloo as a cargo bay payload. This is required because the actual implementation of man's activities in the autonomous operations of the STR is initiated by the man on the Orbiter AFD via the mission and experiment station displays and controls, and especially via man's command inputs to the STR using the computer keyboards on the AFD. The Igloo is essential because the Spacelab subsystem computer and the experiment computer and their supporting subsystems and peripherals are normally mounted in the Igloo and it is through these computers that the man's commands, initiated at the keyboards on the Orbiter AFD, are actually formatted, addressed and directed to the proper parts of the payload for implementation.

Since the payload support subsystem operations and the experiment protocol operations are controlled by the stored software programs in the computer memories, man's ability to intervene in these pre-programmed operations and to modify, revise, repeat or even rewrite the preprogrammed operations from the AFD keyboards gives man direct access and over-riding control of these functional operations out in the cargo bay payload.

Since the Spacelab support subsystems, the STR support subsystems and the DOD experiment functional operations are all fully automated for autonomous operations, the capability for manned intervention and revision of these automated sequences provides a means for man to use his unique capabilities to monitor, control and to optimize the performance of the orbital experiments in real-time, on-the-spot, during the space mission.

For some DOD experiments, the provisions for man to see what the experiment sensor is seeing and to perform fine sensor pointing adjustments will allow the man to use his unique abilities to recognize targets of opportunity and to provide direct control of sensor pointing mechanisms to align the sensor on specific targets being sought. While such functional activities can be automated to some degree, it is usually more cost effective to let the man perform such operations than to develop automated equipments to perform such complex functions, particularly if infrequent usage is anticipated.

In order to use the Spacelab Igloo with the STR as an automated payload, there are some problems that would have to be resolved. The Igloo is normally attached to the Spacelab Pallet as part of its structural mounting in the Orbiter cargo bay. If the STR is used in place of the pallet, it will be necessary to provide the structural support to the Igloo that is normally provided by the pallet structure. Similarly, the Spacelab active cooling loop for the equipment in the Igloo normally utilizes the Dual Freon Pump Package and Accumulator, mounted on the forward edge of the pallet, to circulate freon 21 thru the Igloo cold plates and the Orbiter heat exchanger. It would be necessary to relocate and mount the Freon Pump Package and to provide electrical harness and freon tubing to reconnect this pump package. This would include on/off signal harness from the pump package to the subsystem computer I/O and power cables from the subsystem 400Hz inverter in the Igloo to the dual pump motors.

Electrical and electronics units and cabling on the Orbiter AFD and from the AFD to the Igloo in the Orbiter cargo bay should be available as part of the Spacelab/STS system; however, for Spacelab pallet payloads, the Igloo is normally connected to an experiment remote acquisition unit (RAU) that is mounted on a cold plate on the Spacelab Pallet. It would be necessary to relocate this RAU, perhaps on the STR, and to provide an experiment data bus harness from the Igloo interconnecting station (IS) for the experiment computer I/O unit, to the new RAU location. This RAU also requires a cold plate mounting to dissipate thermal energy and is normally on the Spacelab freon loop for active thermal control. All commands, data signals, and timing signals from the STR and its DOD experiment are routed thru this RAU to the experiment computer and thence to the rest of the Spacelab CDMS and to the Orbiter GPC.

4.4.2.2 Recommendations

While it is evident that the Spacelab equipment can be used to provide manned assistance to the STR and DOD experiments during their orbital operations aboard the Shuttle Orbiter with probable enhancement of the overall experiment results achieved, it will entail additional costs and complexities on any given mission as compared to the cost and complexity of an autonomous STR mission. However, since the Spacelab system will be available and fully integrated and qualified for flight missions on the Shuttle Orbiter, it would certainly be cheaper to use it than to develop fabricate and qualify a similar system of comparable capabilities.

General Electric recommends that the following tasks be further evaluated relative to the potential use of Spacelab equipments to provide manned assistance to STR and DOD experiments aboard the Shuttle Orbiter:

1) Determine which STR/DOD experiments would benefit most from the use of Spacelab equipments.
2) Determine the cost/availability of Spacelab usage relative to the specific DOD experiments' time schedule requirements.
3) Determine the specific functional operations that the Spacelab equipments can satisfy for a typical DOD experiment from Item 1 above.
4) Provide a preliminary design and cost analysis for Item 3 above.
5) Provide recommendations for the DOD experiments identified in Item 1 above relative to their use of Spacelab equipments.

4.4.3 Interim Upper Stage Controls

4.4.3.1 Description

Although a number of studies have been performed, including the two referenced above and others, the current status of IUS controls for use aboard the STS Shuttle Orbiter is confined to a single package of avionics and a single control panel designed for use on the aft flight deck of the Orbiter. Based upon a private telephone conversation between the GE study personnel and a key individual at the Space and Missile Systems Command (SAMSO), Air Force Systems Command, Los Angeles, California, on October 13, 1978, the existing IUS Control Panel is strictly dedicated to the IUS functional operations required. This unit is designed for installation on the Payload Specialist's Station at either panel L 10 or L 11 (See Figure 4-1 shown previously). The avionics electronics associated with this control panel is mounted directly below the panel in volume L 13 or L 14 on the Orbiter aft flight deck. Figure 4-7 shows a block diagram of this IUS Control System.

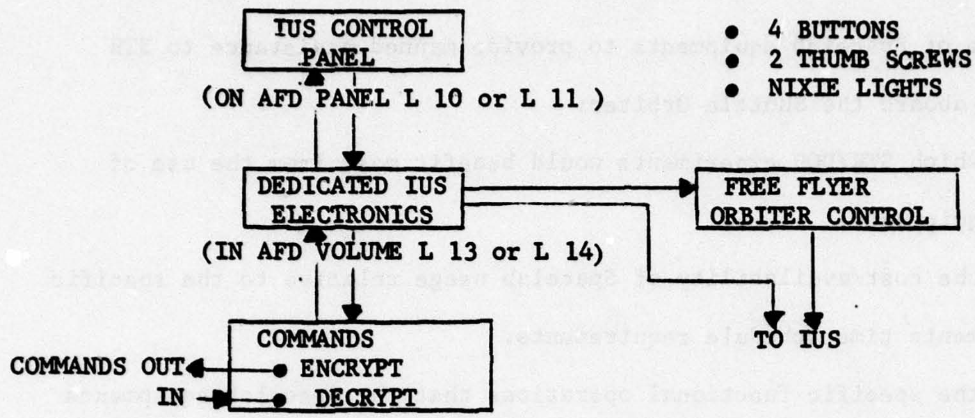


Figure 4-7 IUS Controls Block Diagram

According to the information received in the telecon mentioned above, the IUS Control System that currently exists is unique to the requirements of the IUS functional operations and it is not applicable for use with the Standard Test Rack for any purpose other than control of an IUS should this be included in a DOD experiment in the Space Shuttle.

4.4.3.2 Interfaces

The IUS Control System is designed to fit the standard control panel mountings on the Orbiter AFD and the electronics package is designed to fit the AFD L 13 or L 14 volume dimensions.

4.4.3.3 IUS Evaluation

The current design IUS Control System is not applicable for use with the DOD Standard Test Rack for DOD experiments aboard the Shuttle Orbiter.

4.4.3.4 Recommendations

Although the existing IUS Control System is not applicable for use with the STR, considerable effort is still being expended relative to potential additional equipments that could be developed for use with the IUS. These items include studies of the potential for using the Orbiter General Purpose Computer (GPC) for IUS control, studies of a manual switch panel which would be activated by crew members to control the IUS via talkback indicators, the development of Airborne Support Equipment (ASE) for the IUS, studies of the software requirements if the GPC is used to control the IUS via the Specialists Function control organization in the applications software, etc. Since the computer software and hardware provides a capability for implementing specialist functions as part of the Systems Management functional area in the form of tables of discrete commands, the IUS switching functions could be controlled as part of the existing GPC operations. It is recommended, since so many areas of IUS controls are still under investigation, that the potential for using the IUS controls with the STR be further investigated with the intent of determining if the IUS/STR Control functions have, or could have, major commonalities that would let one unit be used for both STR and for IUS. If practicable, such a common control unit could be especially valuable to DOD because many STS launches that would include IUS stages could also accommodate the STR with various DOD experiments. This combination has added potential economic and operational benefits since, on a normal IUS mission, the IUS is deployed the first day in low earth orbit, and this could leave the STR and DOD experiments in orbit for the remaining 6 days of an STS sortie mission, with the full capabilities of the Shuttle Orbiter and its crew available for STR operations prior to its return to earth.

4.4.4 SSUS Controls

The Solid Spinning Upper Stage (SSUS) is being developed for payloads which will operate in orbits not achievable with the STS. The SSUS is controlled and monitored from the AFD prior to deployment. The Orbiter Control panel and GPC, MDM etc., are utilized as described in Section 4.4.1. Sixteen switches on the standard switch panel and the shuttle keyboard are used for a relatively small number of commands and data points. Hardware and data bus are used. After deployment, the SSUS is controlled by a timed sequence function in the SSUS itself. No unique SSUS equipment exists which could be utilized for controlling DOD payloads.

4.4.5 Teleoperator Controls

4.4.5.1 Teleoperator Controls Description

The Teleoperator Retrieval System (TRS) is a free flying spacecraft deployed from Shuttle which can rendezvous and dock with other spacecraft and provide various subsystems support to them. It also has manipulator arms which can perform servicing functions. The current version is a short life control capability designed to maintain the Skylab Orbit. It has boost, deboost, deployment and retrieval capability. The TRS configuration is shown in Figure 4-8.

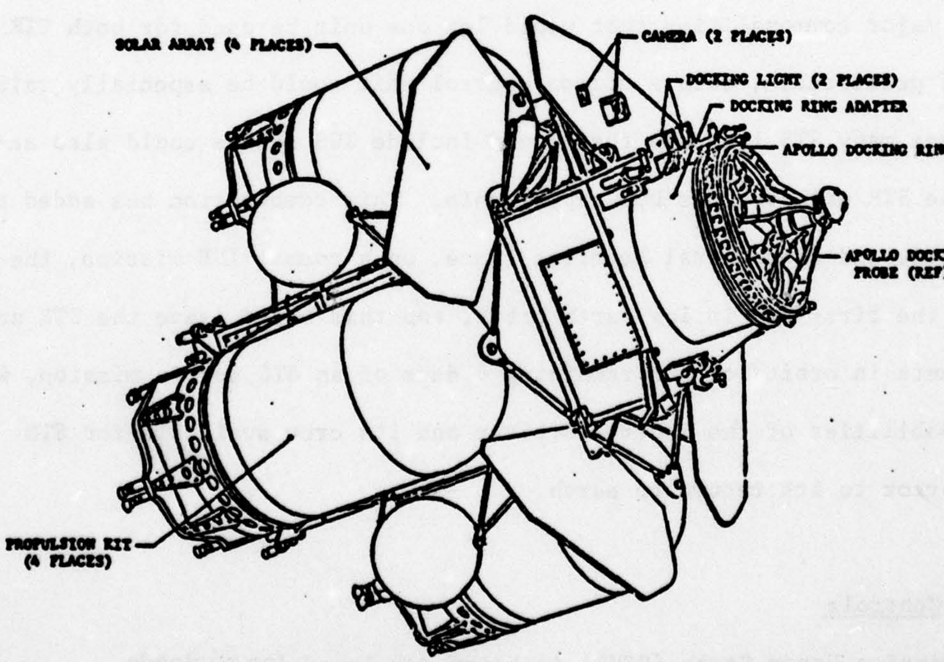


Figure 4-8 Teleoperator Retrieval System Configuration.

The cradle which supports the TRS is shown in Figure 4-9.

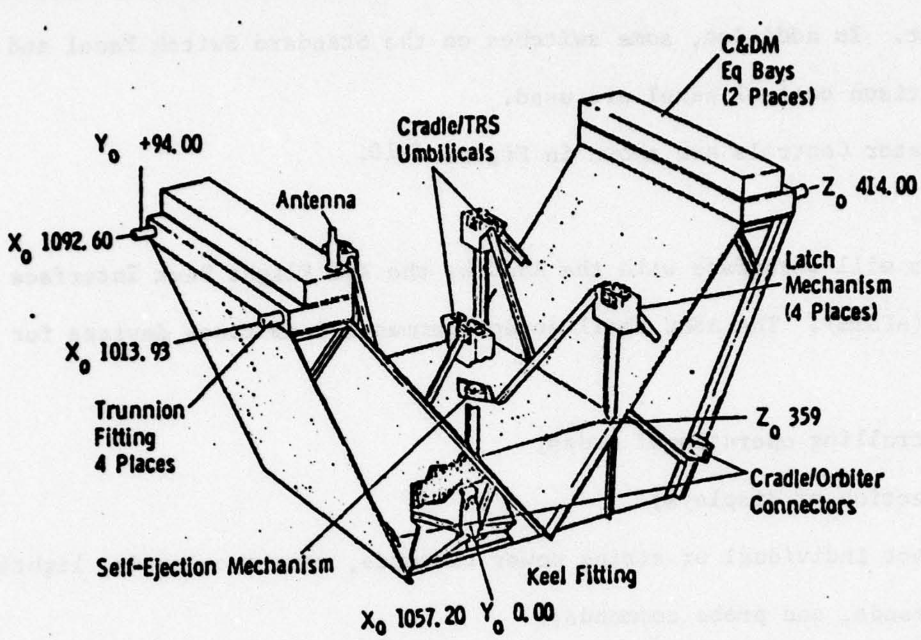


Figure 4-9 Teleoperator Retrieval System Cradle (TRSC)

The Teleoperator is self-deployed from the Orbiter cargo bay, controlled during free flight and rendezvous/docking, and retrieved using the Orbiter RMS and re-secured in the Orbiter cargo bay. All operations are controlled from a dedicated console mounted in the L-11 panel on the AFD. A description of the Teleoperator control system is contained in the following paragraphs.

The Orbiter crewmen will be provided with three devices to interface directly with the Airborne Support Equipment Computer (ASEC) and indirectly with the TRSC for the purpose of controlling and monitoring the TRS Spacecraft. The devices shall be as follows.

a. A terminal consisting of a 32 button keyboard (KBU), a CRT display unit (DU) for video and graphics, and an IBM SPOA computer and associated hardware (DEU);

b. Two hand controllers to control translational and rotational thrusting;

c. A control panel of switches for power application and subsystems management. In addition, some switches on the Standard Switch Panel and the jettison control panel are used.

The Teleoperator Controls are shown in Figure 4-10.

These devices will interface with the ASEC by the Aft Flight Deck Interface Electronics (AFDIE). The ASEC shall accept commands from these devices for the following:

d. Controlling operational modes;

e. Selection of displays;

f. Select individual or string power commands, camera commands, lighting commands, and probe commands;

g. Rotational and Translational hand controller commands.

The DEU will be the primary device for controlling the TRS mission through the selection of mission modes. The mission is divided into major operational modes called OPS modes. These OPS modes describe the state of the ASEC and TRSC required to support the TRS mission phase. The modes are selectable from the DEU keyboard. These modes are defined in Table 4-6.

Table 4-6 Operations Modes Descriptions

OPS Mode	Function
700	IDLE
701	ASE In-Bay Checkout
702	TRS In-Bay Checkout
703	Deployment
704	Rendezvous & Docking
705	Deboost
706	Reboost
707	On-Orbit Storage
708	Retrieval

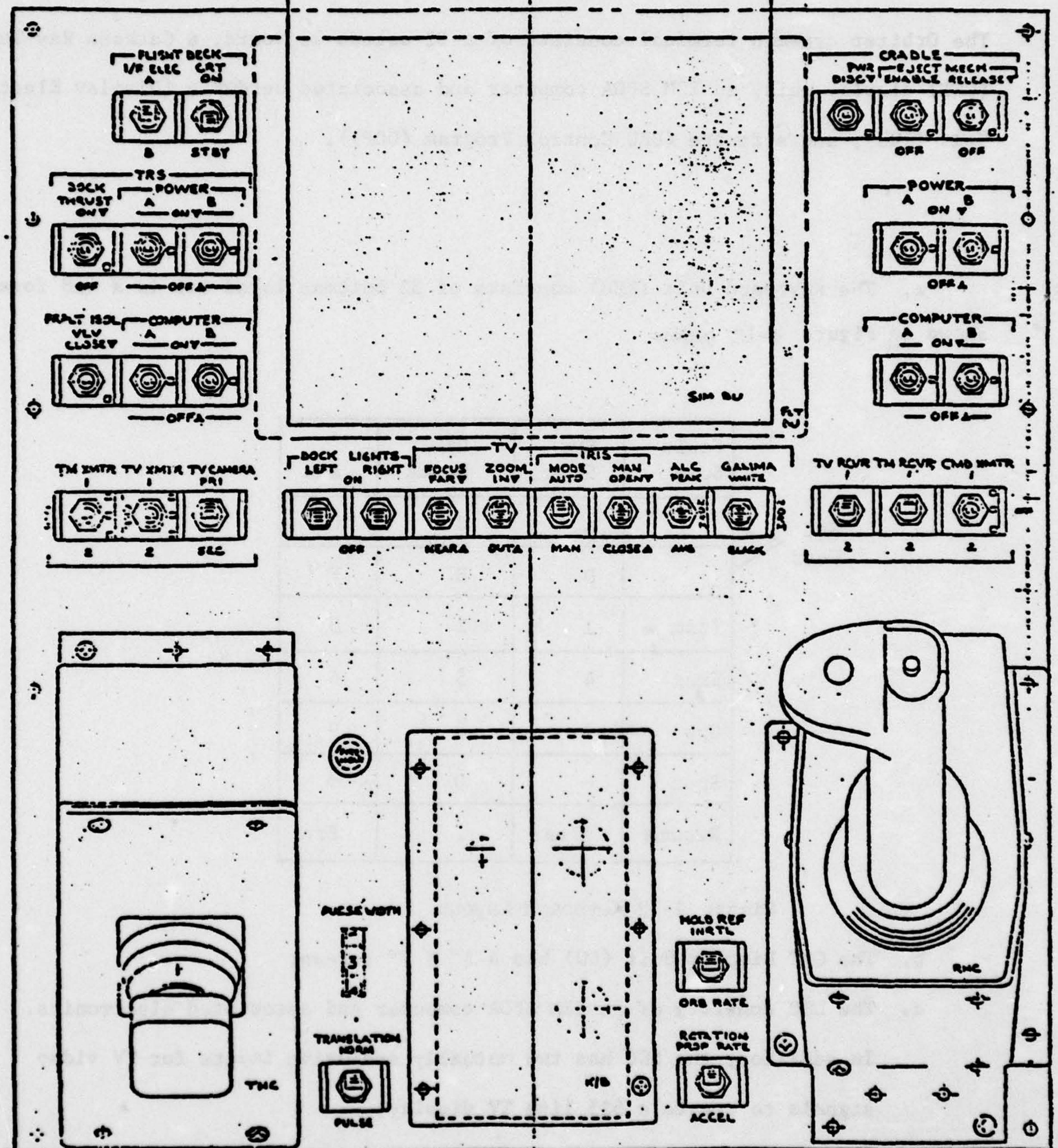


Figure 4-10 Teleoperator Control Panel

All transitions between OPS modes shall be legal. An overview of the Orbiter crewmen interfaces with the TRS Spacecraft is shown in Figure 4-11.

The Orbiter crewmen terminal consists of a 32 button keyboard, a Cathode Ray Tube (CRT) display unit, an IBM SPOA computer and associated hardware (Display Electronics Unit (DEU), and software (DEU Control Program (DCP)).

a. The Keyboard Unit (KBU) consists of 32 buttons layed out in a 4x8 format shown in Figure 4-12, below.

Fault Summ	Sys Summ	MSG Reset	Ack
Not Used	A	B	C
Not Used	D	E	F
Item	1	2	3
Exec	4	5	6
Ops	7	8	9
Spec	-	0	+
Resume	Clear	.	Pro

Figure 4-12 Keyboard Layout

b. The CRT Display Unit (DU) has a 5" X 7" screen;

c. The DEU consists of an IBM SPOA computer and associated electronics. In addition, the DEU has two mutually exclusive inputs for TV video signals to create a 525 line TV display;

d. The Aft Flight Deck Interface Electronics (AFDIE) consists of a Multi-purpose Interface Adapter (MIA) to interface with the DEU and a 24 bit buffer to interface with the ASEC and slow down the bit rate from the

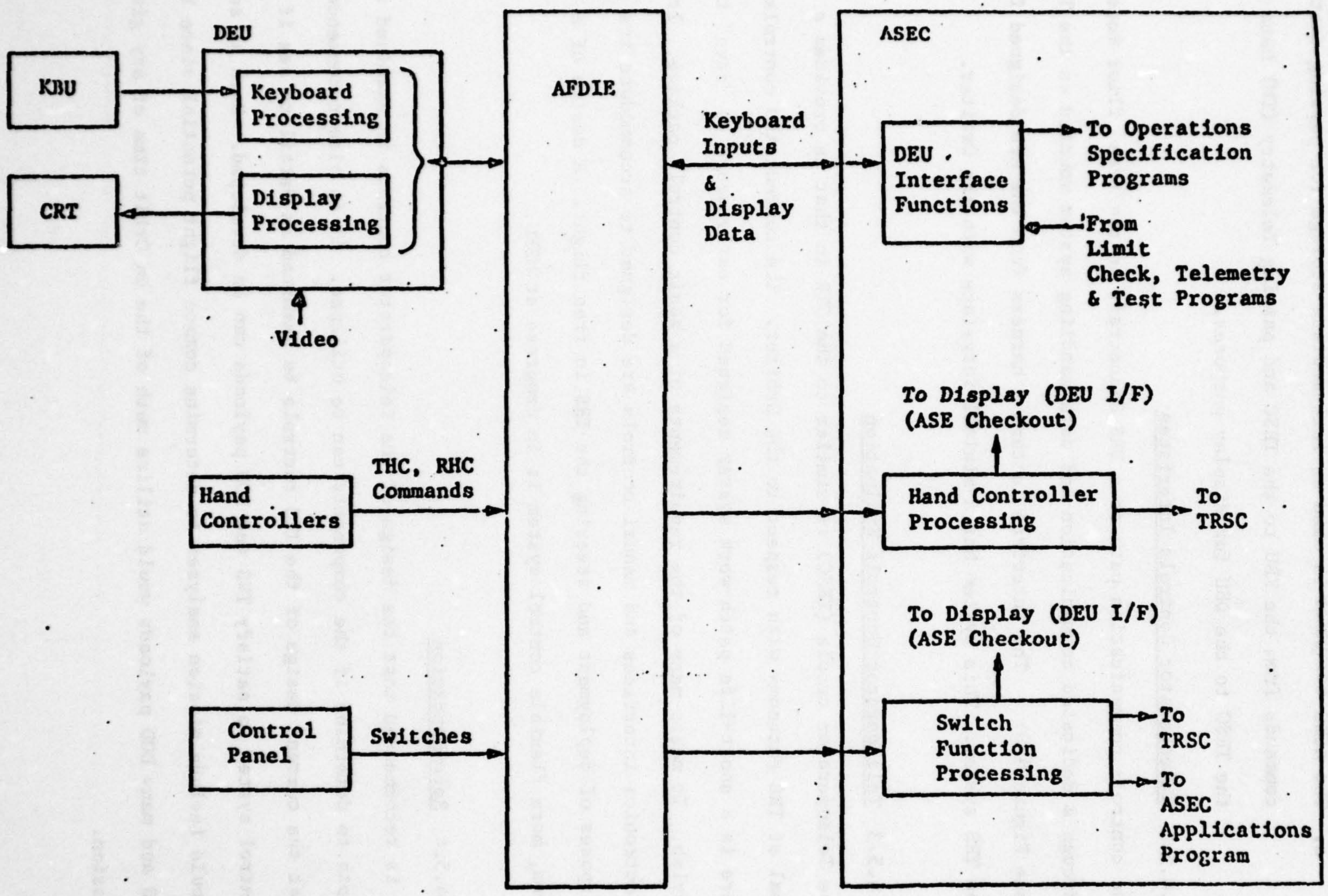


Figure 4-11 Orbiter Crewmen Interface

DEU to the ASEC or speed it up in the opposite direction.

e. The ASEC computer is used as intermediate storage for passing control commands from the KBU to the TRSC and passing Telemetry (TM) Data from the TRSC to the DEU for display purposes.

4.4.5.2 Teleoperator Controls Interfaces

The controls communication path to a TRS Spacecraft in the free flier mode is through a dedicated communication and data handling system mounted on the TRSC (see Figure 4-9) . The interface is thru a harness from the AFD designed for the TRS system. This system has a minimal interface with the Orbiter.

4.4.5.3 Teleoperator Controls Evaluation

The Teleoperator cradle (TRSC) is similar to the STR in that is provides a great deal of TRS autonomy with respect to the Orbiter. The current AFD controls hardware is a short-life patch-work system designed for early usage to "save" the Skylab. It meets many of the requirements of a basic controls package. Its electronics interfaces and manual controls are designed to accommodate its unique purposes of deployment and steering the TRS in free flight. A design of a long term, more flexible control system is in progress at MSFC.

4.4.5.4 Recommendation

It is recommended that the design of the Teleoperator controls be examined in depth to determine if the components can be utilized. It is also recommended that the current design of the TRS controls be examined in detail to see if a control system to satisfy TRS and DOD payloads can be developed. Such an analysis should include mission analyses to determine common flight potential since both TRS and many DOD payloads would utilize much of the on Orbit time of any given mission.

4.4.6 Flight Support System (FSS) Controls For The NASA MMS

The system utilized to support and deploy the NASA standard spececraft (Multi Mission Modular Spacecraft, MMS) is the Flight Support System. It consists of a support cradle with attach and release mechanisms which are controlled from the AFD MCDS panel. A dedicated FMDM is included in the system to minimize the wiring interface between SSUS in the cargo bay and the AFD. A total of 50 commands and 62 telemetry data inputs are provided for the cradle mechanisms, SSUS and its payload.

4.4.7 Dedicated System Description

A typical dedicated Commune and Display (C&D) System for STR experiments is described in Figure 4-13 within the heavy lines.

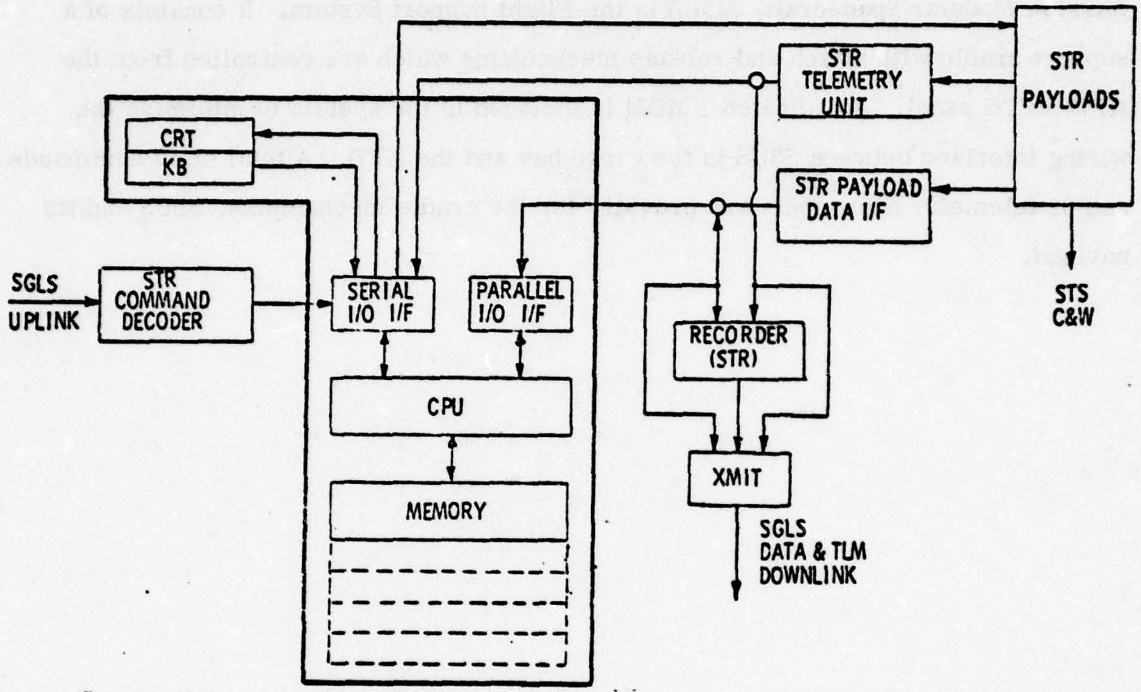


Figure 4-13 Controls and Displays Block Diagram

Key elements of this system are the computer and the CRT/keyboard for display and control. Only the CRT and keyboard must be mounted on the AFD. The other C&D elements within the heavy line can be mounted on the AFD or on the STR in the cargo bay. The elements not enclosed by heavy lines on Figure 4-13 are standard STR subsystems which are used by and interface with the C & D function. The remainder of this section is devoted to a description of a C & D system which would meet performance requirements for support of the STR payloads and would also meet the programmatic requirements of mission to mission adaptability (modular system). Specific items for discussion are CPU, memory and control and display hardware, and operating system software. A treatise on software is presented since software is and will continue to be a cost driver.

4.5.1 CPU and Memory

The computer systems listed on Table 4-7 are typical space qualified equipment that

COMPUTER	POWER	COST	MANUFACTURERS
LSI-11	25 W	$100/200 K	DIGITAL EQUIPMENT CORP.
PDP-1134	300 W	$100/200 K	NORDEN
ALPHA-16	12 W	$500 K	GE (DSCS)
PCS-1880	-	-	PROCESS COMPUTER SYSTEMS (ACPL)
NSSC-1	50 W	$250 K	IBM (FOR NASA)
CDC469	9-20 W	$200-300K	CONTROL DATA CORPORATION

Table 4-7 Typical Computers

are representative of those which could perform the STR payloads task. There are certainly others which could do the job but time and resources did not permit a complete industry survey. If a choice were to be made today, the LSI-II would be selected with the Alpha-16 as a second choice. The primary reason for selecting either of these devices in a typical system is that both are a member of a "family" of computers which are very prevalent among the users of computational equipment i.e. the DEC PDP-11 series. Each of these machines meets all of the requirements defined for STS use. It is emphasized that software considerations drive the hardware choices. The discriminator for recommending these machines is that by virtue of their being members of a broad based, heavily used family of computers the tasks of developing and integrating software to run these machines is made less burdensome. Since new software will be developed for each STR mission this is an important consideration. The following factors support this conclusion:

- A large pool of trained, competant PDP-11 analysts and programmers already exists from which to draw personnel necessary to develop, test, and integrate the software for each STR flight.

AD-A065 097 GENERAL ELECTRIC CO PHILADELPHIA PA SPACE DIV F/G 22/2
STANDARD TEST RACK CONCEPT DEFINITION STUDY.(U)
JAN 79 M GROSS F04701-77-C-0116
UNCLASSIFIED SAMSO-TR-78-145 NL

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- A versitile library of proven support software already exists and can be used directly. This library includes assemblers, compilers, interpreters, linkers, loaders, debug tools, etc.
- A complete repetoire of programming languages is supported. The standard assembler language, Fortran, and COBOL languages are available and it is not necessary to devise new languages.
- Since we have defined a member of a family of computers there is flexability in the system which permits developing and testing flight software on non-flight hardware and then transferring the software to flight hardware without modification.

4.5.2 Display Unit And Keyboard

The capabilities and flexabilities of this unit is a key element in the overall design of the control and display subsystem. There has been a significant amount of work done in defining a display system to support the orbiter payloads control function. Due to the physical constraints on the Aft Flight-Deck a display system supporting multiple functions is required. A summary of available typical multi-function display systems is shown in Table 4-8 . The ideal STR control system is a combination of the systems on Table 4-8 and is illustrated by an * on the items in the referenced table. The CRT/Keyboard display device characterized in Table 4-8 does not exist. However, it is within the capability of existing technology. The concept as illustrated in Figure 4-14 will provide all the control functions required. The display area is large enough to allow meaningful displays to be presented to the payload specialist. There are 2 keyboards available for use by the Payload Specialist. The alphanumeric keyboard allows the maximum flexability for controlling STR payloads. The 4 x 4 programmed function keyboard allows each of the 16 keys to be defined as whatever function is required by the payload being controlled. This provides maximum

Table 4-8 Multifunction Display Systems Summary

COMPARATIVE FACTORS	MFDS (IBM/Norden)	MFDS (Bendix)	SPACELAB
Size of Screen	* 5-in. x 7-in.	8.5-in. x 11-in.	7.5-in. x 10-in.
Color	No	No	* Yes: Red-Green-Yellow
Resolution	83 lines/in.(416 lines)	* 60 lines/in. (525 lines)	
Power - On(watts)	313	* 170	290
Power - Standby (watts)	20	* 20	50
Voltage	* 28 volt DC, 5 volt DC	115 volt, 400 Hz	115 volt, 400 Hz
Weight (lbs)	66	105	* 65
Number of Keys	32 Keys ACSII keyboard + special symbols	60 Keys ACSII keyboard + special symbols	* 78 Keys ACSII keyboard
Resolution - Alphanumeric	* • Large characters--22 lines, 43 characters • Small characters--26 lines, 51 characters	25 lines, 50 characters Status Line- top line Address-bottom 2 lines	21 lines, 47 characters
Graphics - geometric patterns, circles, and vectors	• Vectors (variable length) • Circles (variable diameters)	• Vectors (variable length) • Circles (variable diameters)	• Vectors • Circles
Video	Hardware modification required	* Yes--EIA RS 330 standard format	No
Video with Alphanumeric Overlay	Hardware modification required	* Yes	No
Video with Graphic Overlay	Hardware modification required	* Yes	No
Size of Display and Key-	* Width, 14.9"; Height, 7.4"	Width, 18.0"; Height, 21.8"	Width, 19.0"; Height 24.0"

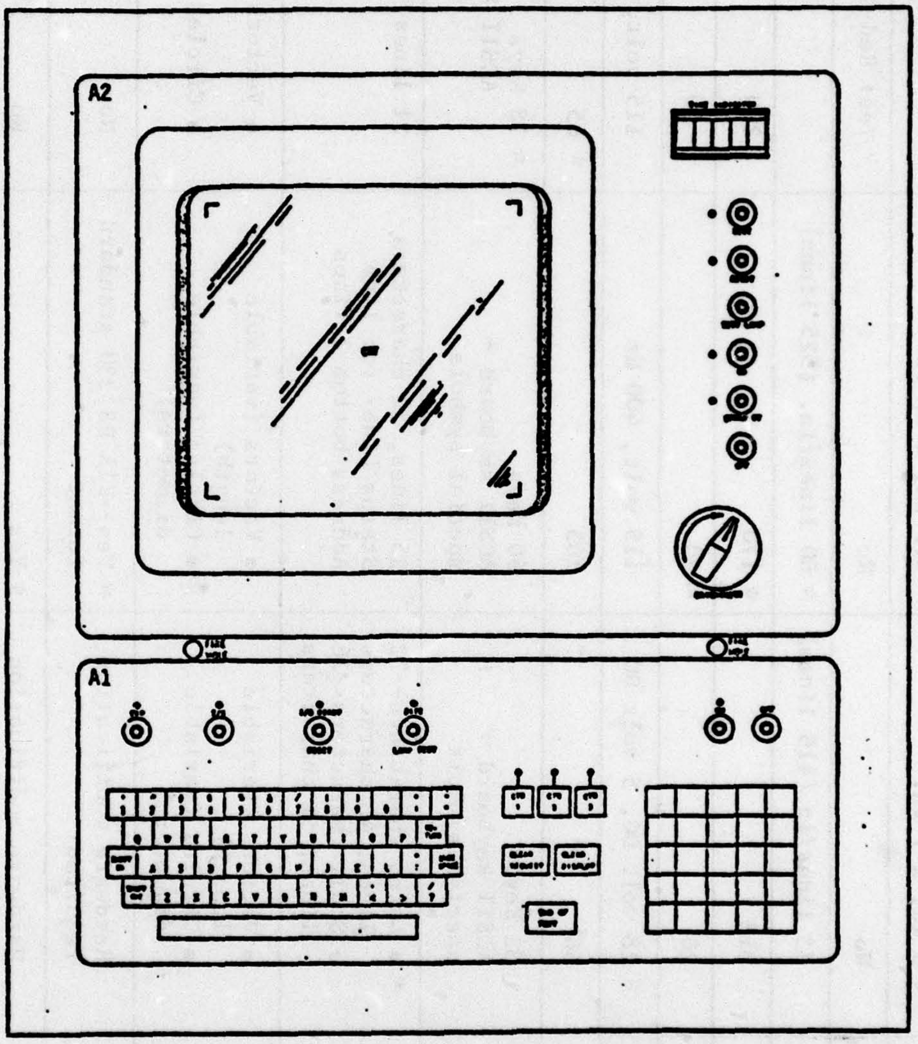

Figure 4-14 CRT/Keyboard Display Device

flexibility within the hardware system.

4.5.2.1 Alternative Concept

In recognition of the fact of life which says that technology is advancing at a rapid rate, GE has identified an alternate control and display concept which advances the state of the art while it simultaneously provides support for both test and operations of shuttle payloads. The device shown in Figure 4-15 could be called a suitcase science data system. All items shown are contained within a briefcase sized device which if developed, could support all control and display requirements of STR payloads from inception through development and test and operations. The device could be stowed in the shuttle (See Section 4.3) and activated as required. Storage would be in lockers A-16 or A-17 on the AFD if available or on the mid-deck below the floor. When retrieved and set-up it could be connected to power and the control system on one of the AFD payload panels. The unit could be operated on the AFD or the mid-deck.

The alternative to self-contained panel mounted equipment is shown in Figure 4-15.

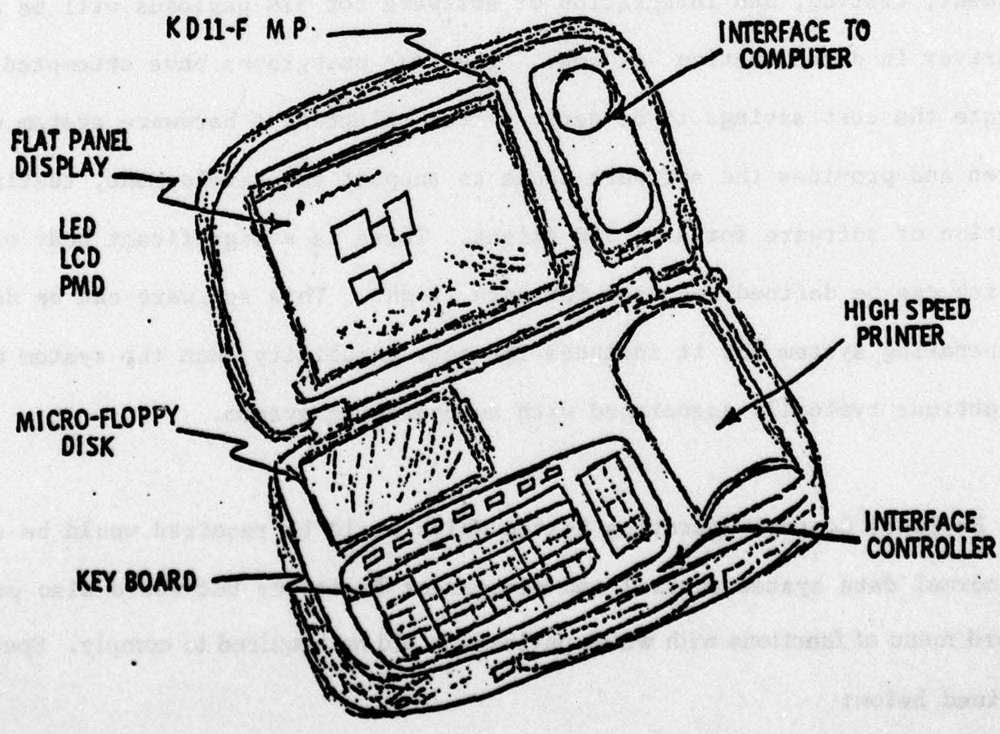

Figure 4-15 Self-Contained Control Equipment

This is a control and display unit which provides a system output medium, an alphanumeric keyboard, and a functional keyboard which can be programmed for any specific function. The unit is a scientific data system control and display unit. It has been designed by R. Croston and Associates of Houston, Texas for the test and checkout of individual experiments by principal investigators in their laboratories. It contains a microprocessor for interfacing but computational capability must be provided by a computer mounted on STR or on an AFD panel. It is proposed that this concept could be extended to the on orbit situation in a manner whereby the control and display for each payload would be a separate suitcase controller, stowed on board on the AFD or in the mid-deck area until needed. This could get around on AFD space problem and increase the number of potential missions on which DOD payloads could be flown.

4.5.3 Payloads Control Software

Development, testing, and integration of software for STR payloads will be a major driver in determination of cost. Previous paragraphs have attempted to illustrate the cost savings to be derived from selecting a hardware system which is proven and provides the software tools to support the development, testing and integration of software for each STR flight. There is a significant body of software which can be defined and used for each flight. This software can be defined as an operating system but it includes far more capability than the system management functions typically associated with an operating system.

The STR Payloads Control Operating System which would be required would be composed of the normal data system control and management functions but would also provide a standard menu of functions with which payloads would be required to comply. Specifics are defined below:

- A table driven display system where each payload element defines graphics and alphanumeric displays to the software system.

- o All payload parameters would be displayed in engineering units and necessary tables to convert raw data to engineering units is required.
- o The software will accommodate interfaces for payload unique programs to acquire and display data.

Perhaps the most delicate data system task for any mission is the integration and test of the set of application software which is going to fly. The delicacy of this task is derived from the fact that there could be single or multiple experiments flying on any one mission. Each experiment has its own goals to be achieved yet the total mission must achieve the goals of many experiments. It is essential that the variables of software development test, and integration be recognized and accommodated in the overall hardware and software system. It is suggested that a well known hardware system be adopted. Concurrently, a well defined software environment should be established. There is a plethora of software options open to a payload developer who hopes to fly on STR. We strongly recommend limiting the application software options open to any payload developer to those shown on Figure 4-16. These options are:

1. Software for control and data display (C&D) using other than the orbiter systems.
2. Software using both C & D and Orbiter systems where orbiter system capability is necessary.
3. Software using the orbiter system only where the need is very small not meriting a separate system.

The key software issue will be putting together a compatible set of mission software. Certain capabilities should be provided as standard functions to which each payload developer must conform. These are: display formats, time acquisition, limits and threshold checking and alarm display and formatting for output.

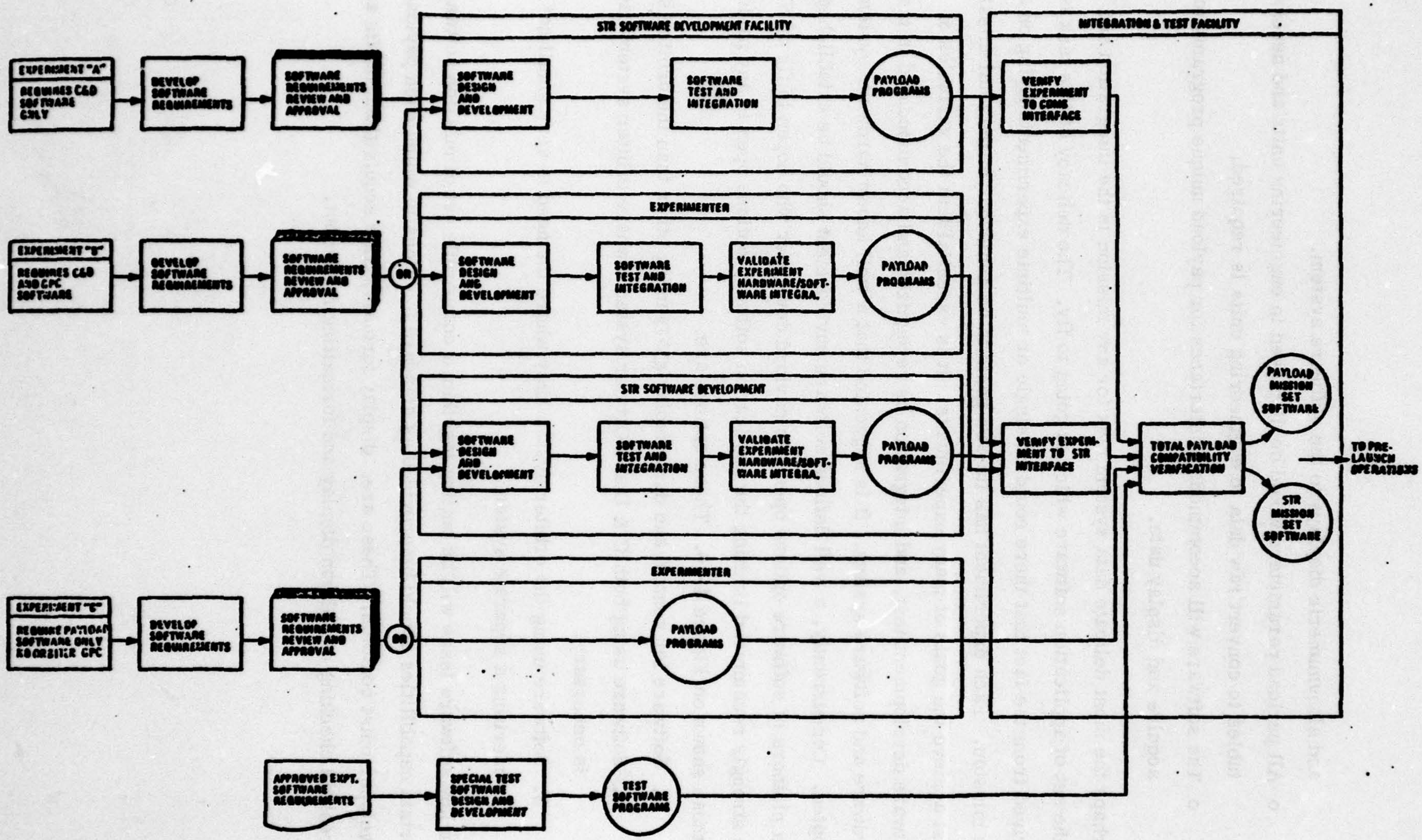

Figure 4-16 STR Payload Software Development Options

4.5 Recommended Equipment

4.5.1 Controls Approach

The best mode of providing control capability for DOD payloads is to utilize a dedicated system located on the Orbiter AFD. This equipment should be augmented whenever possible by the standard orbiter equipment such as the Standard Switch Panel, the video display, the pointing control capability. Even though some missions will not require the full capability or even the use of man, this system designed in a modular concept will provide for the large variety of DOD payloads in the five families identified in this study. The Orbiter and Spacelab controls are not recommended because of competition for their used by Orbiter systems, Spacelab systems and other payloads. Using Spacelab controls would limit the missions to Spacelab flights, since the Spacelab flight schedules will not permit usage of the Spacelab control equipment except on Spacelab flights. In addition, lower software and integration costs are predicted for the dedicated system approach as compared to either Orbiter or Spacelab controls. The dedicated system provides maximum controls availability, minimum interface with the Orbiter and the resulting flexibility and ease of integration characteristic of the full up STR concept.

The dedicated system mode is not without its implementation problems. Such a system would be competing with other payloads and systems for AFD resources such as space, power, cooling, electrical connectors, and crewmen time. Some alternatives are available and have been investigated in this report. (i.e., the self-contained "suitcase" approach to alleviate space crowding).

The dedicated controls approach appears to be the trend as evidenced by the following systems which utilize it. (See Table 4-9)

Table 4-9 Control Mode Survey

USER SYSTEM		CONTROLS		
		DEDICATED	ORBITER	SPACELAB
IUS		X		
SSUS			X	
TRS		X		
ACPL	(Atmospheric Cloud Physics Laboratory)	X		
LIDAR	(Light Detection and Ranging)	X		
MPS	(Material Processing System)	X		
MMS	(Multi-mission Modular Spacecraft)		X	

The SSUS and MMS utilize Orbiter controls for a relatively short period of time to accomplish a system check, latching release and deployment from the Orbiter bay. The ACPL, LIDAR and MPS are Spacelab payloads and still utilize dedicated control approaches (proposed made for LIDAR). Since it is probable that DOD STP payloads would fly with other prime payloads an analysis of the AFD panel space available was made and the results are shown on Table 4-10. The panel availability to STP would depend on what other NASA or DOD payloads fly on any manifested flight.

Table 4-10 AFD Panel Availability

ORBITER PAYLOAD ELEMENT	AFD PANELS * USED	AFD PANELS * AVAILABLE TO NASA AND DOD PAYLOADS	SOURCE OF PANEL USE DATA
IUS	L-11	R11, L10, L12	AF office at JSC
SSUS	R12, HALF L-12	R11, L10, L11, HALF L12	MDAC Telecomm.
MMS	R12, HALF L-12	R11, L10, L11, HALF L12	GSFC Telecomm.
TRS	L-11	R11, L10, L12	MSFC Telecomm.
SPACELAB	R11, L11	NONE TO L10, L12	JSC Meeting & SPAH*

*** Spacelab Payloads Accommodation Handbook, ESA SLP/2104, 30 June 1977.**

A summary of the advantages and disadvantages of a dedicated payload control system is contained in Table 4-11.

Table 4-11 Advantages and Disadvantages of a Dedicated Payload Control System

ADVANTAGES	DISADVANTAGES
• INDEPENDENT OF OTHER EXPERIMENTS • FREEDOM OF FORMAT • EASE OF TEST AND INTEGRATION • NO EXTENSIVE GROUND SIMULATORS REQUIRED • LOWER SOFTWARE COSTS • LOWER SOFTWARE INTEGRATION COSTS • OPTIONS FOR GROUND CONTROL • MINIMAL GSE o SECURITY NEED	• MORE HARDWARE REQUIRED • COMPETITION FOR AFD RESOURCES

4.5.2 Dedicated Controls Equipment List

The resulting list of equipment required is given in Table 4-12.

Table 4-12 List of Dedicated Payload Controls Equipment

- Display Panel
  - CRT (Graphics, Video)
  - Controls
- Display Electronics Unit
- Keyboard (Alphanumeric)
- Switching Module
  - Switches
  - Indicator Lights
- Computer System (Modular)
  - CPU
  - Memories
  - I/O Interface Digital
  - I/O Interface Serial
- Harnesses
- FMDM (STR Mounted)
- Command Encoder (STR Mounted)
- Buffer (Added element)
  - STR Telemetry Unit
  - STR P/L Interface Unit
- Standard AFD Panel
- Support Equipment
  - ECSE
  - Maintenance Kits
    - Cround
    - Airborne
  - Shipping Containers
  - Orbiter Simulator (Limited)

SECTION 5

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